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US/UK COLLABORATIVE TESTS OF BIOLOGICAL DETECTION DEVICES (C)

VOLUME III

PART A

TRIALS, PROCEDURES, AND DETAILS OF THE BIOLOGICAL CHALLENGES (U)

by

(b) (6)

Microbiological Research Establishment, Porton, England

PART B

FIELD TESTS USING ADVANCED DEVELOPED PROTOTYPE MODELS OF THE XM19 ALARM AND OTHER ASSOCIATED EXPERIMENTAL APPROACHES (U)

by

(b) (6)

CB Detection and Alarms Division
Chemical Systems Laboratory

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Chemical Systems Laboratory
Aberdeen Proving Ground, Maryland 21010

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(U)

PREFACE

The work described in this report was authorized under Project 1M764724DF45, Biological Detection and Warning System. This work was started on 29 September 1975 and was completed on 21 October 1975.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

Acknowledgments

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(U)

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VOLUME III

PART A. TRIALS, PROCEDURES, AND DETAILS OF THE BIOLOGICAL CHALLENGES (U)

I. ~~(C)~~ INTRODUCTION.

~~(C)~~ Joint US/UK field tests carried out in 1971[1] with a number of candidate biological detection systems resulted in a decision by the United States to develop a prototype detector (XM19) based on the use of the chemiluminescence reaction. After extensive field testing of the XM19 detector in the United States, a further test program was carried out in the United Kingdom and the Federal Republic of Germany during the latter half of CY 1975.

~~(C)~~ This joint US/UK program (code name DICE) was accomplished in four separate phases. This report is only concerned with phase III.

~~(C)~~ The phase III tests were designed to expose biological detectors in the open air to a series of graded challenges with airborne particles of a biological agent simulant generated in a realistic manner. To allow direct comparisons with the 1971 tests, the location and procedures used for both series of tests were similar whenever this was possible. The program called for challenges to be made by laying down line sources at distances of between 5 and 20 km upwind of the detectors. Thus, all the tests were conducted at the coastal site at Portland Bill[1] using a shipborne spray system.

(U) The biological detection equipment was supplied, maintained, and operated by personnel from the Biological Defense Branch, Defense Systems Division, Development and Engineering Directorate, Edgewood Arsenal, and is described in volume I of this report. The preparation of the challenge material, the collection and assessment of air samples to characterize the test clouds, and the control of the tests were the responsibility of Microbiological Research Establishment (MRE), Porton, United Kingdom.

(U) The United States and the United Kingdom agreed that the phase III test objectives should be:

1. To measure the sensitivity of the detectors to challenges with airborne particles of a biological agent simulant.

2. To measure the response time of the detectors.

3. To measure the mean time between false alarms (MTBFA).

4. To measure the mean time between failures (MTBF).

5. To obtain data for subsequent analyses using alternative alarm logics.

6. To determine the performance of the XM2 biological sampler when operated in conjunction with the XM19 alarm.

(U) A period of 4 weeks was allocated to the phase III program with the aim of delivering 24 challenges. It was provisionally planned that the number of challenges and the distance from the line source to the detector and air sampling site would be:

Distance	Number of challenges
km	
5	10
10	8
20	6

(U) The challenge material was a suspension of phenol-inactivated *Serratia marcescens* (ISM) and a tracer consisting of viable spores of *Bacillus globigii* (BG). For the 1971 tests, the ISM was prepared from pellets of *Serratia marcescens* (SM) supplied by the US Army Chemical Corps. For these tests, the SM was produced by MRE and was not pelletized before inactivation. Details of the methods used to prepare the challenge material are given in appendix A. The nominal cell concentrations in the challenge suspensions were intended to be 2.5×10^{10} per ml of ISM and 0.6×10^{10} per ml of BG; i.e., similar to those used in the 1971 tests. Phenol was present at a final concentration of 0.5% (w/v).

II. (U) MATERIALS AND METHODS.

The materials and methods were very similar to those used previously[1] and, therefore, will not be described again in detail. Four changes worthy of note were as follows:

1. Cyclone sampler: The Aerojet General liquid scrubber all-glass cyclone (AG cyclone)[2] was operated in place of the smaller cyclone used in 1971.[1] The AG cyclone has a higher concentration factor than the model used earlier. Particles from about 800 liters of air are concentrated into 1 ml of fluid per minute of operation.

2. The spraying system: The experimental trials vessel (ETV) Icewhale with its built-in spray system was no longer in service; therefore, an alternative system had to be used. Two multiple spray heads, each carrying 11 jets of the type described by May,[3] were mounted on a specially adapted Land Rover. Compressed air was supplied from a pump driven by the vehicle engine. This complete assembly was secured forward of the bridge on the upper deck of the Fleet Tender Cockchafer. The output of the system could be varied from 1 to 4 liters per minute.

3. Reporting of alarms given by the detection systems: In the 1971 tests, one of the requirements was to measure the response time of biological detectors to the challenges. For this reason, challenges were carried out without notice and blank challenges were included in the program. A dual communications system was used to obviate the detector operators having any knowledge of the time or nature of the challenge. In contrast, the DICE III program did not call for

any immediate notification of alarms or the use of blank challenge material. The US data collection van was linked to the radio telephone network used to control the trials and had direct communications with the trial control center. In practice, the presence or absence of a recognizable signal from the biological detectors was transmitted to the trial controller to assist him in the conduction of the tests.

4. Radar tracking facilities: The radar equipment previously used for tracking the travel of zero lift balloons to measure wind speed and direction over the sea was not reliable due to age and lack of spare parts. For this program, the balloon tracking, the measurement of wind speed and direction at the trial control site, and tracking of the source vessel Fleet Tender Cockchafer were performed by personnel from 22 Locating Battery, Royal Artillery, Larkhill, using the Plessey WF3M wind-finding radar set incorporated in an Army meteorological system (AMETS). Although this equipment was not designed to operate in these roles, it proved to be very successful, and the efficient service provided by this Army detachment contributed to the successful conduct of these tests.

III. (C) RESULTS AND DISCUSSIONS.

(U) During 29 September 1975 to 21 October 1975, 24 challenges were conducted (table 1). Two challenges were failures due to meteorological factors. In one case, challenge 16, there was a large shift in wind direction during the trial, and during challenge 17 the windspeed dropped rapidly during the course of the emission.

Table 1 (C) The Percentage Distribution of Viable BG in Cascade Impactor Samples and Estimates of the Mass Median Diameter (MMD) of the Particles Collected (U)

Cascade impactor stage	Challenges 1 to 11			Challenges 12 to 24		
	N	M	95% CL	N	M	95% CL
1	16	21	16–25	19	29	23–35
2	16	47	43–51	19	46	41–51
3	16	26	22–30	19	20	17–22
4	16	6	4–9	19	5	4–7
Estimated MMD (μm)		6.2			7.6	

NOTE: N = number of samples.

M = mean percentage of viable BG on stage.

95% CL = 95% confidence limits of the mean.

(U) The mean number of agent cloud particles per liter of air (ACPLA) ranged between 1 and 40 and these were distributed as shown below:

ACPLA	Number of challenges
1 to 5	9
6 to 15	6
16 to 25	5
>25	2

(U) After the first 11 challenges at the planned ranges (between 5 and 20 kilometers), it was obvious that, although the challenges reached the sampling site, the concentration of cells in the clouds was not always high enough to yield satisfactory data from the detector system. It was also found that the signals (in millivolts) obtained by the XM19 equipment were lower than expected when tested by the injection of samples of the challenge material. A possible reason for this is discussed below.

(U) A reappraisal of the method of conducting the field tests was made at this juncture and by agreement between the United States and the United Kingdom three changes were introduced for the rest of the program. These were: (1) to increase the number of ISM cells in the challenge material by about 50%, (2) to operate the spray vessel much closer to the sampling site, and (3) to increase the source strength by reducing the speed of the ship and increasing the output of the spray system where possible.

(U) Although these changes in the method of generating challenges resulted in the XM19 detectors registering alarms more often than in the earlier challenges, these changes caused other difficulties. The increase in cell numbers (about 30% more cells were present instead of the planned 50%) resulted in an increase in the solid content of the suspension from 2% to 2.4%. This change was reflected in increases in both the mean number of cells per agent cloud particle (ACP) and the mass median diameter (MMD) of the particles in the challenge clouds. For this reason it has been necessary to treat the results in two groups: those obtained in challenges 1 to 11 and those obtained in challenges 12 to 24.

(C) Reducing the distance between the emission line and the sampling site resulted in the spraying vessel having to operate much closer to Portland Bill than originally intended. This meant that the strong tidal streams and rough water found in the area and, for some wind directions, the proximity of the ship to the Shambles Bank and the presence of other shipping restricted the challenges to what could safely be achieved in the prevailing conditions rather than having the greater flexibility available at longer ranges. Some of the later challenges were carried out in far from favorable conditions for the personnel operating the spray vessel.

(U) The Challenge Suspensions.

1. (U) Estimates of Cell Numbers.

Estimates of the total cell numbers in the samples collected from clouds containing ISM and viable BG are based on the recovery of viable BG. This requires a knowledge of the ratio of viable BG to ISM contained in the suspension used to generate the clouds.

Viable counts of the BG content of the challenge material were made on samples collected during each of the challenges. Duplicate assays were made from each sample.

In an attempt to estimate the number of ISM cells in each sample, direct microscopic counts of wet preparations were made. This procedure was not satisfactory because of the difficulty in counting all of the ISM cells present in the preparation. An alternative method, suggested by (b) (6) at MRE, was finally adopted. Films were prepared from well-mixed samples and then stained with hot malachite green and counter-stained with dilute carbolfuchsin so as to distinguish between spores and vegetative cells. Between 300 and 1000 cells were counted in each sample with the aid of a ruled eyepiece. Replicate films were prepared from two samples known to contain different concentrations of cells to obtain some measure of the reproducibility to be expected from this method. The results from these assessments are summarized in table 2.

Table 2 (U). Results of the Microscopic Assessments of the Ratio of ISM to Viable BG in the Challenge Materials

Material	Number of samples	Ratio of ISM to viable BG		
		Range	Weighted mean*	95% Confidence limits of weighted mean
Challenge 6	5**	1.27-2.09	1.79	1.41 to 2.09
Challenges 1 to 11	11	1.72-3.34	2.42	2.10 to 2.78
Challenge 21	5**	3.19-5.85	4.60	3.47 to 6.11
Challenges 12 to 24	13	2.98-7.55	4.58	3.93 to 5.36

* Log normality assumed.

** Replicate films from one sample.

Individual assessments made on each of the challenge suspension samples in the two groups of challenges, 1 to 11 and 12 to 24, showed that the variation between samples was not very different from that found between replicate assessments made on a single sample from each of these groups. Therefore, it was decided to use the weighted mean ratios of ISM/BG to estimate the ISM cell concentration for each of the challenges by applying these ratios to the measured viable BG counts. For challenges 1 to 11, the ISM count was estimated by multiplying the viable BG count by 2.42; for challenges 12 to 24, a factor of 4.58 was used. The estimated ISM cell concentrations determined by this treatment are shown on the data summary sheets in appendix B.

2. ~~(C)~~ Reduction in Chemiluminescence Signal.

~~(C)~~ The signals recorded when known numbers of ISM from the challenge suspensions were injected directly into the XM19 alarm in liquid suspensions were lower than expected when compared with those found with the same numbers of cells from the pool of ISM prepared for these trials and from other batches of SM prepared at MRE and elsewhere. A possible explanation lies in the method used to prepare the challenge suspensions (appendix A). To reduce the concentration of phenol in the challenge suspensions to 0.5%, some of the supernatant fluid was removed from the ISM pool prepared for this program which initially contained ca. 3% phenol. Subsequent work at MRE has shown that a substantial proportion of the haem-containing components of a bacterial suspension may be present in the supernatant fluid.*

3. (U) Size Range of Particles in the Challenge Clouds.

The size range of particles in the challenge clouds for the two groups of challenges, 1 to 11 and 12 to 24, are shown in table 1. The effect of the increased solids in the material used for challenges 12 to 24 is reflected in an increase in the MMD. This is also shown graphically in figure 1.

4. (U) Mean Numbers of Cells in Agent Cloud Particles.

The ratios of cells (ISM and BG) to ACP obtained with four combinations of air samplers, i.e., cyclone and cascade impactors and slit samplers collecting at either 2 or 8 liters per minute, are given in table 3. The additional cells present in the suspensions used for challenges 12 to 24 resulted in an appreciably higher number of cells per ACP in these tests than in challenges 1 to 11.

In an earlier report,[1] we commented on the problem of trying to estimate, with any certainty, the mean number of cells contained in an ACP when using cell samplers of differing efficiency and particle samplers of differing sensitivity. The wide fiducial limits attached to the mean values shown in table 3 reemphasize the large variance associated with this measurement.

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* (U) [redacted] (b) (6) MRE Report (to be published). Luminol – Chemiluminescence and the Rapid Detection of Microorganisms.

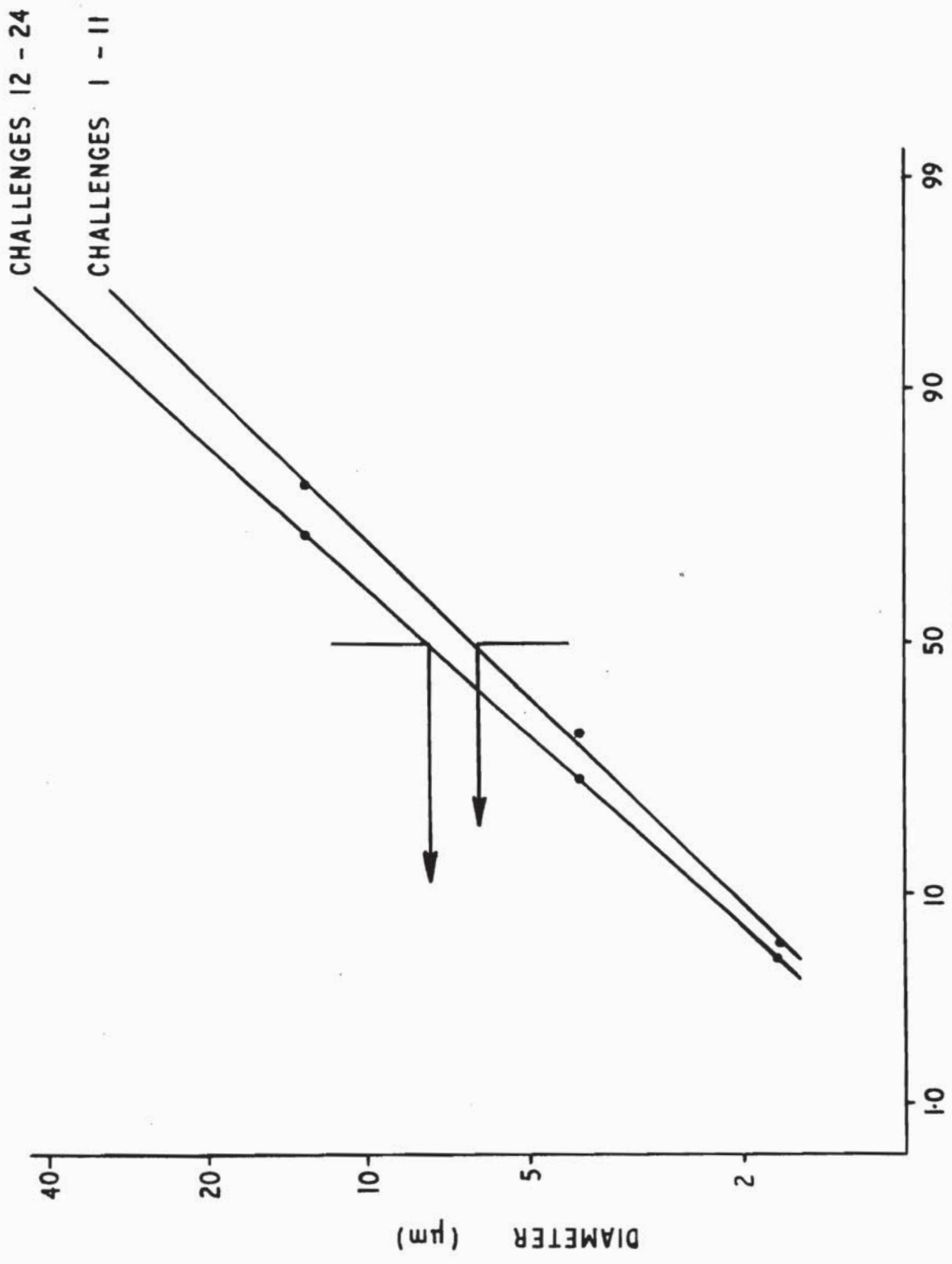


Figure 1 (U). Size Distributions of Airborne Particles Collected with the Cascade Impactor

Table 3 ~~(C)~~. Estimated Mean Numbers of Cells in Agent Cloud Particles (ACP) with Different Combinations of Cell and Particle Samplers (U)

Cell sampler	Particle sampler	Challenges 1 to 11			Challenges 12 to 24		
		N	M	95% CL	N	M	95% CL
Cyclone	2 ℓ/min S–S	9	37	23-52	8	53	26-79
Cyclone	8 ℓ/min S–S	11	24	17-32	6	40	22-58
Cascade impactor	2 ℓ/min S–S	8	32	22-43	8	53	33-73
Cascade impactor	8 ℓ/min S–S	6	28	20-35	4	47	28-66

NOTE: S–S = slit sampler.

N = number of sampler pairs.

M = arithmetic mean of cells per ACP.

95% CL = 95% confidence limits of the mean.

5. (C) Results of the Biological Assessment of the Challenges.

(C) Results of the biological assessment of the challenges are summarized in tables 4 and 5 and presented in appendix B in the same form as that used in 1971.[1] For each of the challenges, there is a map of the trial area showing details of the emissions. The wind speed and direction given were recorded at the sampling site at Portland Bill using a Porton anemograph 2 meters above ground level. Following the map is (a) a page summarizing the results of the biological assessment of viable BG and estimates of total cell numbers (ISM and BG) and (b) a figure showing ACP concentration measured with the slit samplers. Cloud concentrations are expressed as mean numbers of cells and mean numbers of ACP per liter of air.

(U) When a spray system such as the May nozzle, which generates a heterogenous aerosol, is used to generate the challenge cloud, the use of ACP to characterize the cloud can be misleading. For example, with a suspension containing 2.5×10^{10} cells per milliliter and a total solid content of 2%, the numbers of cells to be expected have been calculated for three different size particles typically present in the challenge clouds. In this example, it has been assumed that the particles generated by a May spray have dried completely before sampling, but even if this is not the case the relative numbers of cells per particle will be the same as for the completely dried particles. The values calculated are:

Dry particle diameter	Expected number of cells per particle
μm	
3	18
5	82
7	225

Table 4 — Summary of Characteristics of the Challenges (U)

Challenge number	Date, 1975	Time cloud present at sampling site (BST)	Distance from line source to sampling site	Characteristics of suspension		Characteristics of spray			
				Total cells, $\times 10^{10}$/ml	ISM/BG ratio	Output	Cells per ACP	Cells, $\times 10^{10}$, per meter of track	ACP, $\times 10^{10}$, per meter of track
			km			ml/m			
1	29 September	1546–1553	5.7 to 7.9	2.94	2.42	8.4	36	24.7	0.69
2	30 September	1233–1235	4.3 to 5.0	3.18	2.42	10.3	26	32.8	1.26
3	30 September	1326–1329	3.3 to 5.0	2.80	2.42	12.7	31	35.6	1.15
4	30 September	1412–1414	5.0 to 5.9	3.11	2.42	10.8	24	33.6	1.40
5	1 October	1505–1509	11.3 to 13.9	2.98	2.42	9.8	18	29.2	1.62
6	1 October	1631–1634	11.1 to 14.5	3.11	2.42	9.1	16	28.3	1.77
7	1 October	1752–1757	11.1 to 12.6	2.33	2.42	10.8	15	25.2	1.20
8	3 October	1429–1431	6.5 to 8.6	2.05	2.42	9.0	21	18.5	0.88
9	3 October	1602–1605	2.4 to 7.3	2.12	2.42	17.5	54	37.1	0.69
10	3 October	1710–1740	3.1 to 6.1	1.98	2.42	17.0	39	33.7	0.86
11	6 October	1417–1434	21.7 to 26.7	2.26	2.42	11.9	25	26.9	1.08
Mean 1–11								29.6	1.15
12	13 October	2258–2309*	4.8 to 7.4	2.46	4.58	8.5	41	20.9	0.51
13	13 October	0015*	3.3 to 5.7	2.90	4.58	13.5	20	39.2	1.96
14	15 October	1903–1906*	3.2 to 7.0	2.96	4.58	11.5	41	34.0	0.83
15	17 October	1247–1253	2.5 to 5.2	2.85	4.58	22.5	58	64.1	1.11
16	17 October	**							
17	18 October	**							
18	19 October	1910–1911*	3.5 to 6.6	3.96	4.58	12.8	28	50.7	1.81
19	19 October	2028–2033*	2.0 to 4.0	2.79	4.58	18.1	49	50.5	0.95
20	19 October	2123–2124*	3.0 to 4.0	2.62	4.58	19.4	53	50.8	0.96
21	21 October	1242–1245	3.7 to 5.0	2.46	4.58	22.3	48	54.9	1.14
22	21 October	1340–1343	3.0 to 5.7	2.46	4.58	14.7	113	36.2	0.32
23	21 October	1502–1507	3.7 to 5.3	2.06	4.58	24.2	46	49.9	1.08
24	21 October	1544–1546	3.1 to 4.8	2.57	4.58	14.4	58	37.0	0.64
Mean 12–24								44.4	1.03

NOTE: BST = British standard time.

*Trials carried out after dark.

**No BG recovered.

Table 5 ~~(C)~~ Summary of the Biological Results from the Challenges (U)

Challenge number	ACP per liter (8 liters per S–S)		Cells per liter, mean		MMD	Cells per ACP (8 liters per S–S)		Time cloud present at sampling site
	Mean	Peak	ISM and BG	ISM		ISM and BG	ISM	
					μm			min
1	23	47	743	526	5.9	35	25	5.75
2	5.6	15	206	146	5.4	23	16	2.50
3	12	29	375	265	5.6	25	18	2.50
4	10	20	233	165	6.4	19	13	2.50
5	1.4	4	24	17	4.4	18	13	4
6	2.7	7.5	44	31	4.8	16	11	2.50
7	2.6	7.5	49	35	4.0	17	12	4.25
8	5.3	13	120	85	5.6	20	14	2.25
9	30	99	1590	1125	7.6	45	32	2.50
10	4.3	19	169	120	6.2	26	18	13.75
11	2.6	13	66	47	8.3	24	17	16.75
12	2.0	7.5	78	64	7.0	37	30	10.50
13	1.7	2.0	33	27	a	20	16	0.75
14	6.2	17	269	221	7.0	48	40	3
15	20[b]	48[b]	1173	963	7.6	58[b]	48[b]	5.25
16	c							
17	c							
18	5	9	190	156	5.0	28	23	1.50
19	40	70	1398	1147	8.0	49	40	4.50
20	19	54	1461	1199	9.6	59	48	1.75
21	17[b]	38[b]	719	590	8.0	48[b]	37[b]	3.50
22	17[b]	52[b]	1904	1663	7.8	113[b]	93[b]	3
23	10[b]	30[b]	537	441	7.4	46[b]	38[b]	5
24	10[b]	30[b]	555	455	6.6	58[b]	48[b]	2.25

[a] Data not available.

[b] Based on recoveries with slit samplers collecting at 2 liters per minute. Eight-liters-per-minute slit samplers were collected, but the plates were too heavily populated for accurate assay.

[c] No BG recovered.

These values are not very different from the numbers of cells observed microscopically in tests in which BG was disseminated from a low-flying aircraft.[4]

(U) In a recent program of tests[5] to calibrate biological detectors in the field using suspensions containing varying concentrations of cells, it was shown that the detector response was much less sensitive to variations in cell concentrations in the challenge material when related to cells per liter of air than to ACP per liter of air.

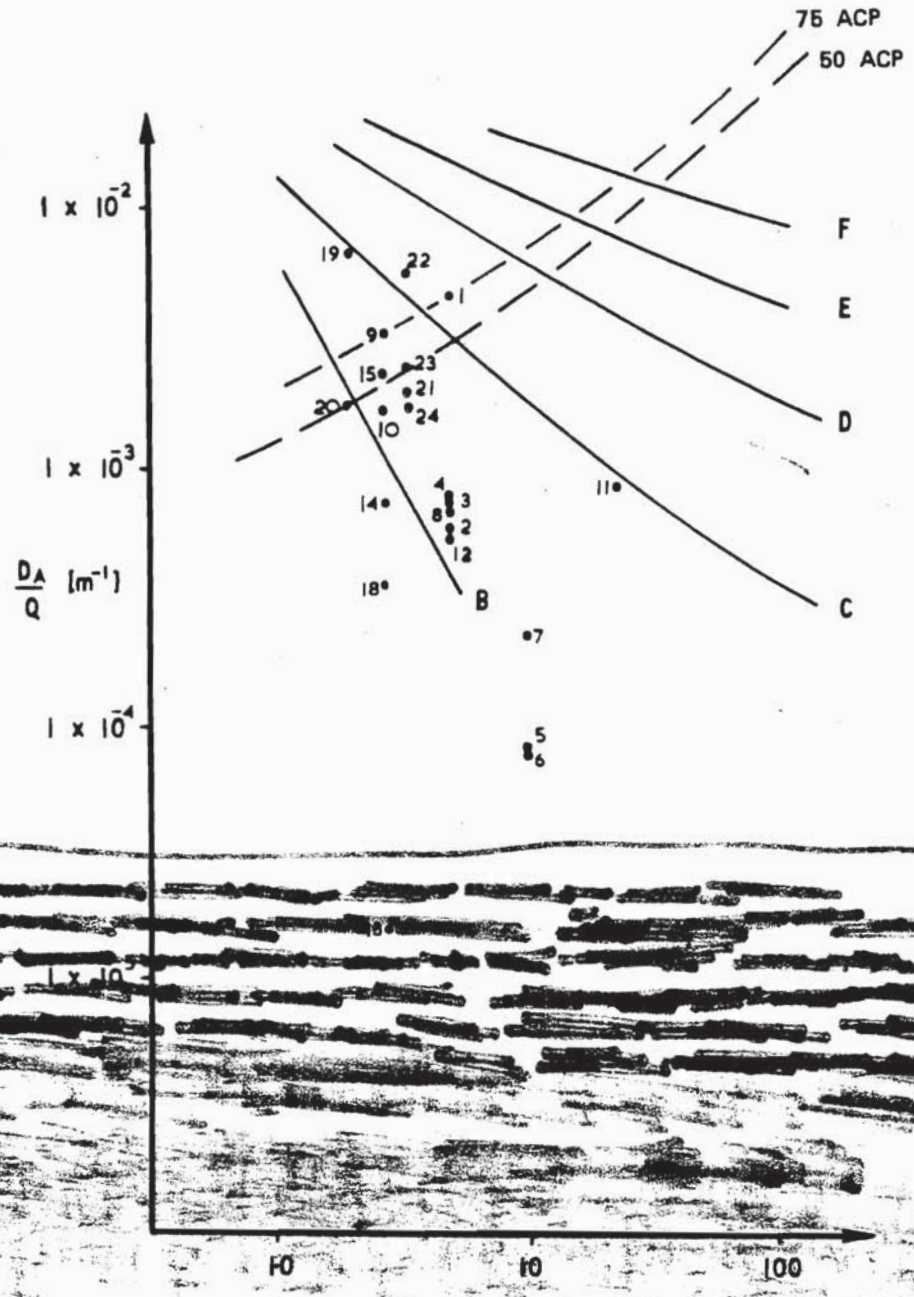
(U) As the infectivity of airborne microorganisms is measured in laboratory experiments in numbers of cells, it is essential to know the responses of a detector to cells per liter of air as well as to ACP per liter of air.

6. (C) Limitation of Cloud Concentrations That Can Be Achieved with the Spray System Used.

(C) As pointed out above, considerable difficulty was experienced in achieving challenge levels equal to the sensitivity requirement of the XM19 alarm (75 ± 25 ACP). In fact, despite increasing the concentration of the material in the spray fluid and decreasing the range, the peak concentration only exceeded 75 ACP in one challenge (No. 9).

(C) One factor which undoubtedly contributed to this difficulty was the meteorological regime existing over the sea off Portland Bill during the trial period. At this season of the year, the sea is frequently warmer than the air which leads to strong vertical mixing. Also, during much of the trial period, there was strong insolation which

(b) (1) (A)



AREAL DOSAGE FOR UNIT SOURCE STRENGTH, D_A/Q m^{-1}
• DATA POINTS
—— THEORETICAL CURVES
– – – PREDICTED VALUES FOR A PEAK CONCENTRATION OF 75 ACP PER LITRE WITH A SOURCE STRENGTH OF 10^{10} ACP PER METRE

Figure 2 ~~(C)~~: Areal Dosage for Unit Source Strength, $D_A/Q\ m^{-1}$ (U)

(C)

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[redacted (b) (1) (A)]

(C) PART B. FIELD TESTS USING ADVANCED DEVELOPED PROTOTYPE MODELS OF THE XM19 ALARM AND OTHER ASSOCIATED EXPERIMENTAL APPROACHES (U)

I. ~~(C)~~ RESULTS AND DISCUSSIONS.

A. (C) Analysis of Data.

(C) Response of Detectors. Table 6 summarizes the millivolt response of the XM19 alarm and XM19 alarm modified by Bendix Corporation and known as the "batch processor" model (BXTR) when subjected to ISM-BG clouds ranging from 1.4 to 40 agent cloud particles per liter of air (ACPLA). Results of the biological challenges during the US/UK collaborative test in 1971* indicated that an aerosol particle generated in the field contained 17 to 25 cells (mean), 50% of the particle mass being in particles 5 to 6 μm in diameter. The nominal cell concentration for these trials (trials 1 through 11) were similar to those used in 1971 and the cells per ACP (mean) were 24 based on assessment of the 8 liters per minute slit sampler. All biological alarms had significant millivolt increases to challenges $\geq$6 ACPLA (144 cells per liter of air). None of the alarms were capable of detecting <4.3 ACPLA (103 cells per liter of air). These results are comparable with those on the performance of the Chemi 2 in the joint US/UK trials conducted in 1971* which indicates that design, fabrication, and packaging of the chemiluminescence process has not downgraded performance.

B. (C) Probability of Detection.

(C) The data from the ISM-BG field study indicate that the XM19 and BXTR alarms were very similar in operation (tables 6 and 7). The 95% probability of detection level was 10.5 ACPLA (252 cells per liter of air) for all biological alarms (figure 3).

~~(C)~~ The maximum net millivolt responses lasting 90 successive seconds recorded by the XM19 and BXTR alarms to the various 90-second-level ACPLA concentrations of the ISM-BG challenges are summarized in table 8. The data from this field study indicate a millivolt/ACP value for the challenge material (ISM-BG) of approximately 31 for the XM19 alarm and 26 for the BXTR alarm.

C. (C) Analysis of Background Responses (False Alarms).

(C) Data collected during the test period were analyzed for false alarms at alarm logic threshold settings ranging from 60 to 600 mv representing an equivalent of 2 to 20 ACPLA (48 to 480 cells per liter of air). The logic used for detection of alarms (both false and real) for the XM19 and BXTR alarms is described in section II of volume I.

* ~~(C)~~ [redacted] (b) (6) EASP 1300-5. Joint US/UK Collaborative Field Tests of Biological Detection Devices (C). January 1973. CONFIDENTIAL Report.

Table 6 ~~(C)~~ Peak Millivolt Response of Detectors to Particle Concentration (U)

Trial number	ACPLA			Detector					
	Mean[a]	Range	Average	XM19-SN13	XM19-SN18	XM19-SN19	XM19-SN21	BXTR No. 1	BXTR No. 2
19	40	>25	35	1200	3070	1860	b	1960	1100
9	30			1590	3950	1300	1840	4545	1690
1	23			1460	1845	1124	3000	1726	1430
15	20			1500	1910	1990	1860	1080	2950
20	19	16-25	19.2	670	960	610	715	500	540
21	17			320	460	370	750	700	830
22	17			1160	1905	1865	2460	2695	1815
3	12			285	400	290	505	695	270
23	10			670	1175	395	660	360	490
4	10	6-15	8.9	260	290	215	370	340	220
24	9.8			330	420	380	450	385	490
14	6.2			180	170	575	532	195	490
2	5.6			175	170	185	390	370	130
8	5.3			c	320	c	390	c	c
18	5.0			c	c	c	c	c	c
10	4.3			202	305	754	270	355	405
6	2.7			c	c	c	c	c	c
7	2.6	1-5	3.1	c	c	c	c	c	c
11	2.6			c	c	c	c	c	c
12	2.0			c	c	c	c	c	c
13	1.7			c	c	c	c	c	c
5	1.4			c	c	c	c	c	c

[a] For trials 1 through 11, the MMD was 6.2 μm and the mean number of cells per particle = 28; for trials 12 to 24, the MMD was 7.6 and the mean number of cells per particle = 50.

[b] Detector off line.

[c] No response to challenge.

Table 7 (U) Probability of Detection of XM19 and BXTR Biological Alarms (U)

Challenge level (ACPLA)	Number of challenges in range	XM19-SN13		XM19-SN18		XM19-SN19		XM19-SN21		BXTR No. 1		BXTR No. 2	
		Number of challenges detected	Percent of challenges detected	Number of challenges detected	Percent of challenges detected	Number of challenges detected	Percent of challenges detected	Number of challenges detected	Percent of challenges detected	Number of challenges detected	Percent of challenges detected	Number of challenges detected	Percent of challenges detected
1-5	9	1	11	2	22	1	11	2	22	1	11	1	11
6-15	6	6	100	6	100	6	100	6	100	6	100	6	100
16-25	5	5	100	5	100	5	100	5	100	5	100	5	100
>25	2	2	100	2	100	2	100	1*	100	2	100	2	100

* Unit was off line throughout trial 19.

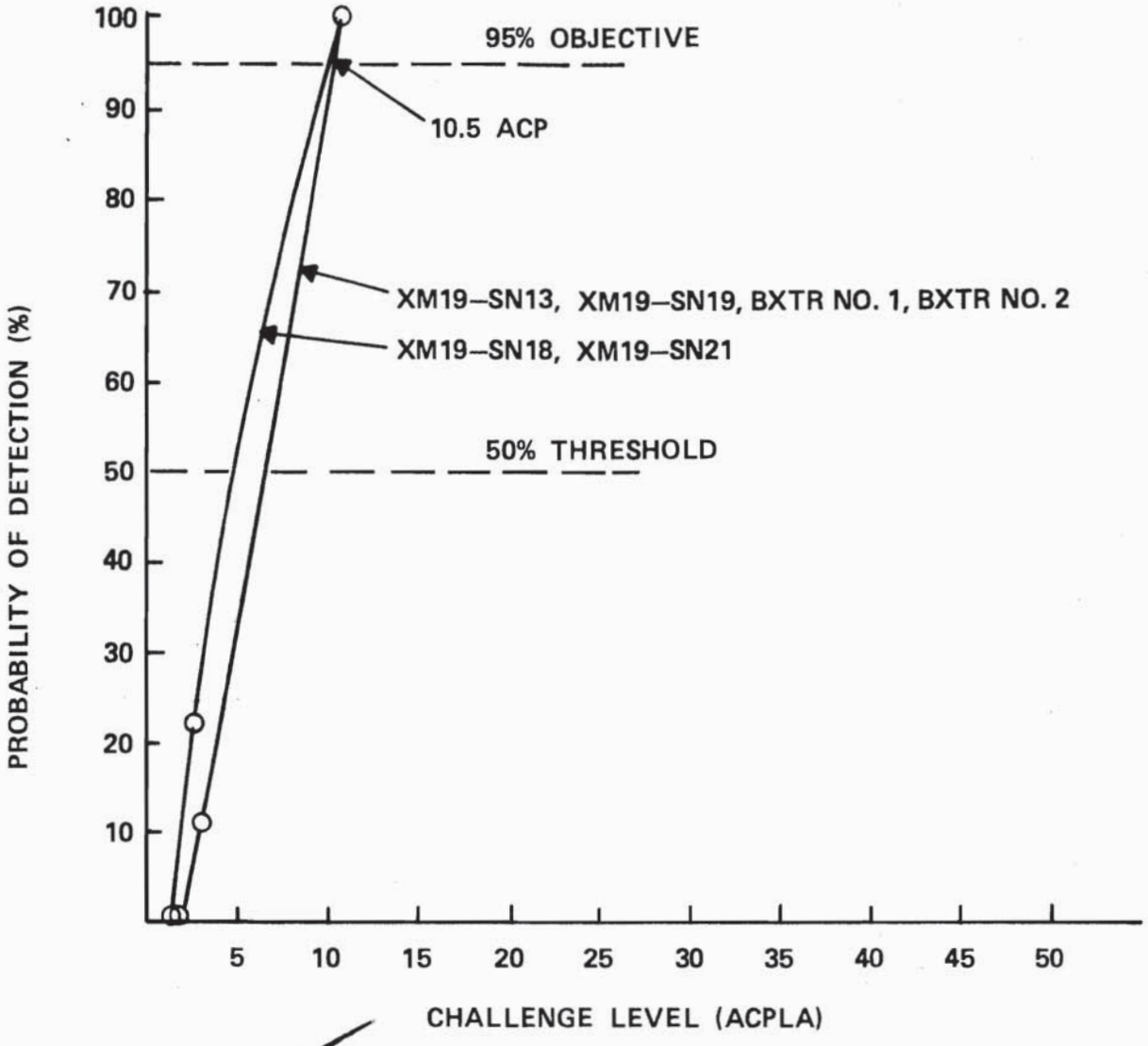

Figure 3 (C). Probability of Detection for XM19 and BXTR Biological Alarms (U)

Table 8 (C). Average Millivolt Response of XM19 (Four Devices) and BXTR (Two Devices) Alarms to Field Challenges of Phenolated-*S. marcescens* (ISM) Where Net Response and ACPLA Level Lasted 90 Seconds on Target (U)

Trial number*	ACPLA (90-second level)	XM19 (four devices)		BXTR (two devices)	
		Net response	MV/ACP	Net response	MV/ACP
		mv		mv	
1	33	1278	38.7	885	26.8
9	15	495	33	538	35.9
15	30	968	32.3	785	26.2
19	39	917	23.3	340	8.7
21	7	200	28.6	**	**
22	31	915	29.5	460	14.8
			Mean 30.9		Mean 22.4
				Without No. 19 (one cloud station), low responses and bimodality	25.9

*Trials 1 through 11 – MMD = 6.2 μm and mean number of cells per particle = 28.
Trials 12 through 24 – MMD = 7.6 μm and mean number of cells per particle = 50.

**No measurable response.

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(C) A false alarm is a response which satisfies the alarm logic but is not due to the presence of a biological agent or simulant nor caused by improper operation or maintenance. Multiple false alarms resulting from one equipment malfunction or closely spaced in time (within 10 minutes) will be considered one false alarm. False alarm occurrences and the maximum net millivolt response for the XM19 alarm are recorded in table 9. (The BXTR had no false alarms.) Also, table 9 gives the ACPLA equivalent based on the millivolt per ACPLA found for inactivated *Serratia marcescens* used for the open-air challenges and stated above. The false alarms encountered at the various ACPLA equivalence levels (represented in millivolts) and the hours of operation are summarized in table 10 for the XM19 and BXTR alarms. The mean time between false alarms (MTBFA) at the various threshold levels are summarized for each type of alarm in table 11. The XM19 alarm (four devices) responded 51 times at ACPLA levels ≥ 2 while operating 260 hours at Portland Bill; the BXTR alarm (two devices) responded zero times at the same ACPLA equivalent level while operating 216 hours. It is evident that the BXTR alarm performed substantially better than the XM19 alarm.

(C) The desired MTBFA is 200 ± 50 hours with 95% probability of detection threshold set at 75 ± 25 ACPLA (1800 ± 600 cells per liter of air). Thus, the alarm's sensitivity to ACPLA may be traded off to reduce the number of false alarms. The MTBFA was plotted against ACPLA (ISM equivalence levels), figure 4.

(C) The curve indicates that the XM19 alarm can meet the desired 150 hours by setting the threshold at 11 ACPLA (ISM equivalent) thereby insuring a 95% probability of detection of 16 ACPLA (384 cells per liter of air).

(C) The BXTR alarm had no false alarms in 216 hours at a threshold setting of 2 ACPLA (ISM equivalent). Therefore, it appears that the BXTR alarm could function in a Portland Bill-like background and be capable of detecting 7 to 10 ACPLA (168 to 240 cells per liter of air) with virtually no false alarms at a detection probability of 95%.

II. (C) CONCLUSIONS.

(U) The XM19 alarm and the BXTR alarm detected biological aerosols of inactivated *Serratia marcescens* reliably in the field in the presence of background particulates and are approximately equal in sensitivity.

(C) The MTBFA at the 95% probability of detection level of 11 ACPLA (264 cells per liter of air) is 52 hours and 216 hours for the XM19 and BXTR alarms, respectively. About 16 ACPLA (384 cells per liter of air) and 7 ACPLA (168 cells per liter of air) can be detected at the 95% probability of detection level and meet the objective of 150 hours MTBFA for the XM19 and BXTR alarms.

(U) It has been demonstrated that the BXTR alarm has the better potential of meeting the characteristics specified in the required operational capability (ROC) dated 12 March 1975 for a biological agent simulant in a relatively clean environment. Further tests will be required to demonstrate its performance to other types of agents and in less favorable environments.

(U) The operational and design information gained from this study was very valuable and will significantly aid in the engineering development of an acceptable, fieldable alarm for Army use.

Table 9 (U). XM19 Detector Response, 50 mv and Greater, Resulting from Atmospheric Background at Weymouth (Portland Bill) (U)

Detector	Time	Date, 1975	Response*	ACPLA** equivalent
			mv	
XM19 (SN13)	1513	29 September	80	3
	1543	29 September	90	3
	1715	29 September	60	2
XM19 (SN18)	1404	29 September	50	2
	1205	30 September	50	2
	1510	3 October	220	7
	1705	3 October	80	3
	1554	9 October	70	2
	1334	13 October	90	3
	1490	13 October	60	2
	1425	13 October	90	3
	1916	15 October	50	2
	1949	15 October	180	6
	2042	15 October	70	2
	1522	16 October	100	3
	1536	16 October	90	3
	1554	18 October	100	3
	1806	19 October	60	2
	2015	19 October	50	2
XM19 (SN19)	1341	30 September	440	15
	1320	2 October	60	2
	1340	3 October	100	3
	1657	3 October	70	2
	1303	6 October	90	3
	1451	6 October	50	2
	1454	7 October	60	2
	1547	7 October	60	2
	1327	10 October	210	7
	1536	10 October	60	2
	1950	15 October	60	2
	2054	15 October	50	2
	1159	17 October	50	2
	1819	19 October	80	3
	2008	19 October	60	2
XM19 (SN21)	1404	29 September	50	2
	1545	29 September	110	4
	1204	30 September	50	2
	1219	30 September	50	2
	1630	3 October	50	2
	1657	3 October	70	2
	1749	6 October	90	3
	1623	10 October	70	2
	1743	10 October	50	2
	2011	13 October	50	2
	1741	15 October	100	3
	1940	15 October	50	2
	2020	15 October	70	2
	1153	17 October	50	2
	1555	18 October	50	2
	2040	20 October	420	14
	1312	21 October	50	2

*Maximum net voltage lasting 90 successive seconds.

** Based on 30 mv/ACPLA as obtained with phenol-inactivated *S. marcescens* (ISM) during Portland Bill trials.

Table 10 ~~(C)~~ XM19 and BXTR False Alarms at Various Threshold Levels (U)

Alarm	Site	Threshold in mv*									Hours
		60	90	120	150	180	210	300	450	600	
XM19	Portland Bill	51	19	6	5	5	4	2	1	0	260
BXTR	Portland Bill	0	0	0	0	0	0	0	0	0	216

*Based on 30 mv/ACPLA as obtained with phenol-inactivated *S. marcescens* during these trials, the threshold levels indicated represent 2, 3, 4, 5, 6, 7, 10, 15, and 20 ACPLA, respectively. Cells per liter of air equals the ACPLA times 24.

Table 11 ~~(C)~~ MTBFA (Hours) at Various Threshold Levels for XM19 and BXTR (U)

Alarm	Site	Threshold in mv*								
		60	90	120	150	180	210	300	450	600
XM19	Portland Bill	5	14	43	52	52	65	130	260	>260
BXTR	Portland Bill	>216	>216	>216	>216	>216	>216	>216	>216	>216

*Based on 30 mv/ACPLA as obtained with phenol-inactivated *S. marcescens* during these trials, the threshold levels indicated represent 2, 3, 4, 5, 6, 7, 10, 15, and 20 ACPLA, respectively. Cells per liter of air equals the ACPLA times 24.

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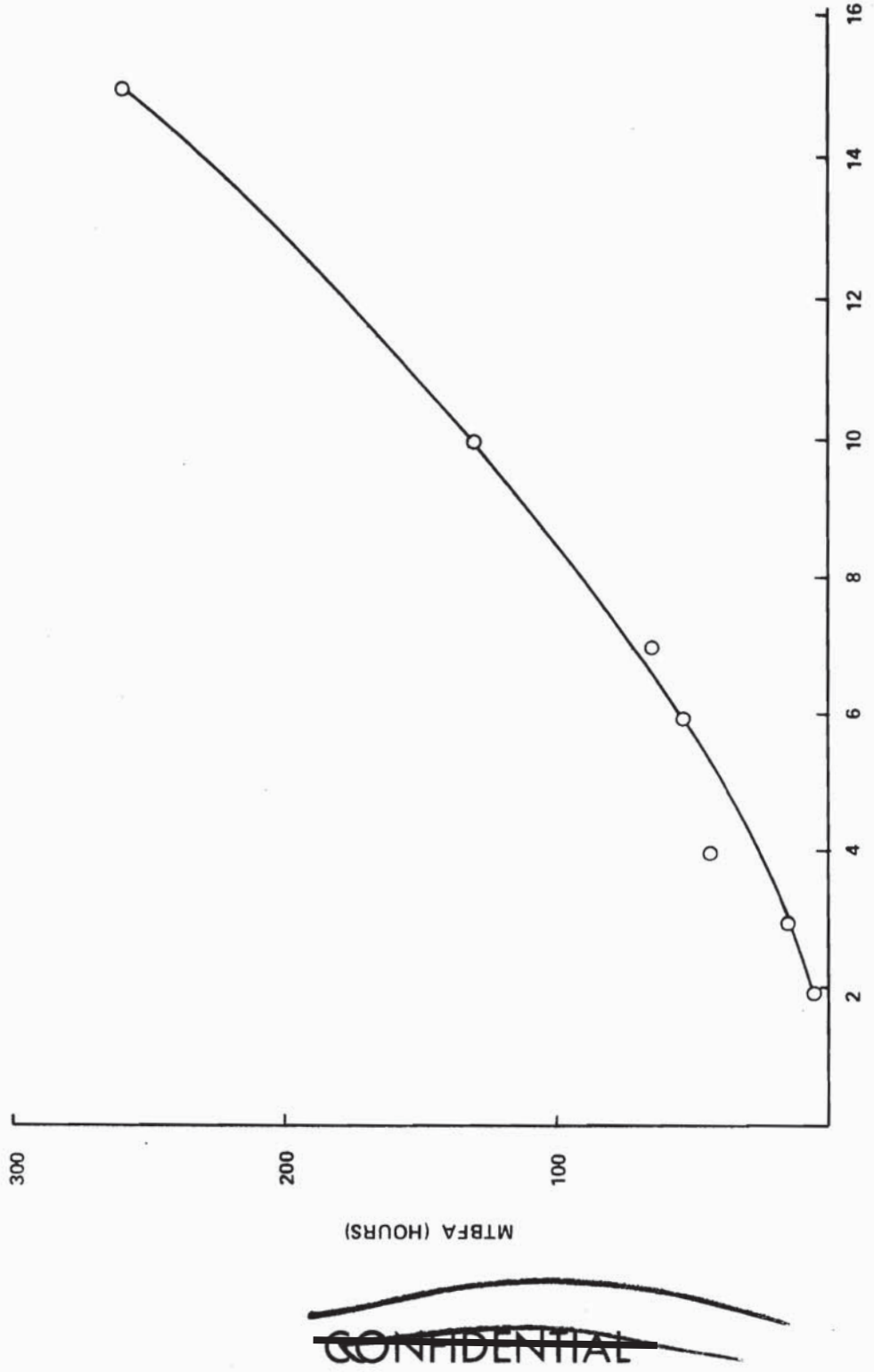

Figure 4 (C) Mean Time Between False Alarms (MTBFA) Versus Detection Level for XM19 at Portland Bill (U)

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(U)

APPENDIX A

THE PREPARATION AND CHARACTERISTICS OF BACTERIAL SUSPENSIONS SUPPLIED BY THE EXPERIMENTAL PLANT FOR DICE III FIELD TRIALS

(b) (6)

MRE, Porton, England

(U) THE PREPARATION AND CHARACTERISTICS OF BACTERIAL SUSPENSIONS SUPPLIED BY THE EXPERIMENTAL PLANT FOR DICE III FIELD TRIALS

This program was based on the supply of blended suspensions containing phenol-inactivated cells of *Serratia marcescens* UK8 (ISM) at a concentration of 2.5×10^{10} cells per milliliter together with 0.6×10^{10} per milliliter of live *Bacillus globigii* var *niger* heat-activated spores (BG). The estimated demand was for a maximum of 3000 liters of suspension to be dispensed in 50 stainless steel kegs each containing 60 liters. This would require 7.5×10^{16} cells of ISM plus 1.8×10^{16} BG spores overall.

The production and storage of similar numbers of BG spores has been described previously, but UK8 (ISM) production has been limited to the 20-liter scale. Thus, pretrial development was undertaken to determine the feasibility of large-scale UK8 production, phenolation, storage, and suspension preparation.

A summary of this work together with the production method employed for the final blended suspensions is given below.

1. Pretrial Development.

a. Large-Scale Culture of UK8.

Five 400-liter cultures were grown in the development program. The first two batches were produced utilizing identical conditions to those developed for the 20-liter vessel during program 1/74. This method employs the same culture medium plus glycerol as that used for *Escherichia coli* MRE 162 production. However, differences in overall culture characteristics coupled to excessive foaming necessitated some modification.

It was found that reduction in culture time from 25 to 15 hours overcame foaming but reduced the cell yield by 20%. This method did, however, give a consistent basis for cell production over the final three cultures and was, therefore, adopted.

b. The Phenolation and Storage Properties of UK8.

Inactivation of UK8 had previously been effected by the slow addition of a 90% phenol solution until the contents of the fermenter attained a 1% overall concentration. However, this level proved ineffective on the 400-liter scale and, in an attempt to determine the most efficient concentration, 1%, 1.2%, 1.5%, and 2% phenol levels were investigated. Both 1.5% and 2% phenol were found to be totally and immediately lethal while 1% and 1.2% steadily reduced the number of viable cells to zero over a 2-month period.

Comparison with results from the 20-liter cultures revealed a completely different pattern of lysis, as measured by relating change in cell dry weight, between phenolated and unphenolated cells. In program 1/74, a sharp, immediate drop in the dry weight of phenolated cells was observed, whereas a slower, steadier, and reduced loss occurred with these batches of

UK8. This was independent of the concentration of phenol employed or the culture conditions. The UK8 from large-scale batches would, therefore, seem to have phenolation properties parallel to those exhibited by MRE 162.

To examine the microbiological stability of the stored product, 20-liter jerrycans from each of the five cultures and representing all phenol treatments were stored at 4°C, together with unphenolated controls, for a 2-month period. During this time, no perceptible outgrowth by either surviving UK8 or contaminating organisms was observed.

After this term of storage, the phenol concentration was reduced by dilution to 0.5% – the level specified for the trials – and the suspension was monitored for a further 14 days at room temperature. Again no deterioration in cell numbers or quality of UK8 cells was observed.

c. Analytical Control.

Throughout this development work, UK8 cells were subjected to periodic estimates of total dry solids, cell dry weight, bacteriological purity, viable cell count, and percent phenol. Samples were also submitted to Field Trials Section so that the viable counts could be duplicated, but more importantly, so that the chemiluminescence reaction could be checked.

It was also considered necessary to introduce a new control technique to eliminate any possibility that the phenol was carried over in the Miles and Misra counting method. This might happen especially when low counts were involved, the bacteriostatic action of the phenol producing erroneous results. The following method was therefore used:

One milliliter of culture was added to 9 ml of sterile water and passed through a sterile 47-mm Millipore 0.22-μm filter held in a Sterifil aseptic system. The filter was then washed through with 2 × 10 ml of sterile water to remove any traces of phenol and transferred directly onto the surface of a trypticase soy broth agar plate. An aseptic technique was employed throughout this procedure. After incubation at 34°C for 24 hours the bacterial colonies were counted.

A typical series of results is given below:

Viable count (Miles and Misra) colonies/ml	Viable count (Millipore) colonies/ml
754	1215
1244	1595
1566	1500
849	1460
239	1601
700	1000
960	1200

With one exception, the Millipore technique gave consistently higher counts in the above example and therefore provides a useful method of control. Equally it demonstrates that the growth of large numbers of UK8 cells is not inhibited by residual phenol.

2. Preparation of a UK Stock Suspension.

A total of 6 × 400-liter cultures of UK8 was grown for this program at the rate of two per week. After additions of 2% phenol, each culture was stored at 10°C in a 500-liter plastic tank for 24 hours until cleared for use by the previously-mentioned control procedures.

The suspensions were then successively pooled in a 1000-liter plastic tank, the settling properties of the cells being used to reduce the volume. This was effected by pumping off the clear supernatant between cultures, thereby reducing the 2400 liters of suspension to 725 liters. This pool contained 11×10^{16}-inactivated UK8 cells as estimated by dry weight ratios and total cell counts.

Although 2% phenol was used, differential distribution of the phenol between the cells and culture fluid resulted in a rise in the phenol concentration to 3.2% as the cell concentration increased.

This suspension, held at 10°C, was regarded as the UK8 stock. From this, appropriate volumes were drawn, after stirring to ensure a homogeneous product, and used for blending purposes. To ensure a uniform and stable product, the standard control techniques were applied every 3 days throughout the program.

3. Preparation of Blended Suspensions.

Blending may be defined as the process by which bacterial suspensions of the correct working strength are prepared. This process has previously been described.

During DICE III, 19 barrels were supplied each containing 60 liters of a blended suspension consisting of 0.6×10^{10} heat-activated BG spores per milliliter plus 2.5×10^{10} phenol-inactivated UK8 cells per milliliter. The phenol concentration was 0.5% and less than 100 viable UK8 cells per milliliter were present. The concentrated stocks of UK8 and BG spore suspensions were diluted with tap water to attain these levels.

Due to a low chemiluminescence response, it was decided to increase the UK8 content of the suspension to 4×10^{10} cells per milliliter. A further 31 barrels were therefore prepared to this new specification which resulted in an increase in phenol concentration to 0.7%.

In addition to the list of analytical controls given in the previous section, viable BG spore counts and percent white variant counts were carried out on all barrels both at the time of preparation and dispatch. Interim storage was at 4°C and no qualitative or quantitative change in the material was observed during this time.

Discrepancies between total cell counts and dry weight ratio estimations led to the introduction of an additional method to determine inactivated UK8 cell numbers. By carrying out a normal spore stain using 5% malachite green and counterstaining with 5% Mercurochrome, it was possible to count the ratio of green spores to red UK8 cells in a sample of suspension. This ratio could be related back to viable spore counts thus obtaining an independent value for the numbers of UK8 present. For example, dry weight ratios indicated 2.5×10^{10} UK8 per milliliter while spore-to-cell ratios (maximum 4:1, minimum 3.5:1) suggested values of 2.1 and 2.4×10^{10} UK8 per milliliter.

Fifty stainless steel barrels of suspension were prepared in total, only 42 being dispatched. Thus DICE III required a theoretical total of 10.29×10^{16} inactivated-UK8 cells plus 1.8×10^{16} heat-activated BG spores.

(C)

APPENDIX B

RESULTS OF TRIALS 1-24 (U)

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Table B-1 ~~(C)~~

PROGRAMME 21/75 SERIAL 1 DATE 29 Sept. 75 CHALLENGE 1

MATERIAL SPRAYED ISM/BG TIME SPRAYED 15.35 to 15.55 VOLUME SPRAYED 60 litres

LENGTH OF SPRAY LINE 7130 m. RANGE TO SAMPLING SITE 5650 to 7880 m

MEAN WIND SPEED 3.5 to 6.0 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	3944	1367	4884	1164
CASCADE IMP	1844	1085	1951	1148
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	952	119		
2 L/MIN			224	112
TIME OF CLOUD ARRIVAL	15.47½		15.46¼	
TIME OF CLOUD DEPARTURE	15.52¾		15.52	
TIME CLOUD PRESENT (MINUTES)	5¼		5¾	
MEAN CELLS/LITRE				
CYCLONE	260		202	
CASCADE IMP	207		200	
MEAN PARTICLES/LITRE	23		19	
PEAK PARTICLES/LITRE	47		44	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	11.3		10.6	
CASCADE IMP/SLIT SAMPLER	9.0		10.5	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	13		14	
2	57		56	
3	23		26	
4	7		4	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	889	691
CASCADE IMP	708	684
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	39	36
CASCADE IMP/SLIT SAMPLER	31	36

SUSPENSION VIABLE BG 0.86×10^{10}/ml

ESTIMATED SM 2.08×10^{10}/ml

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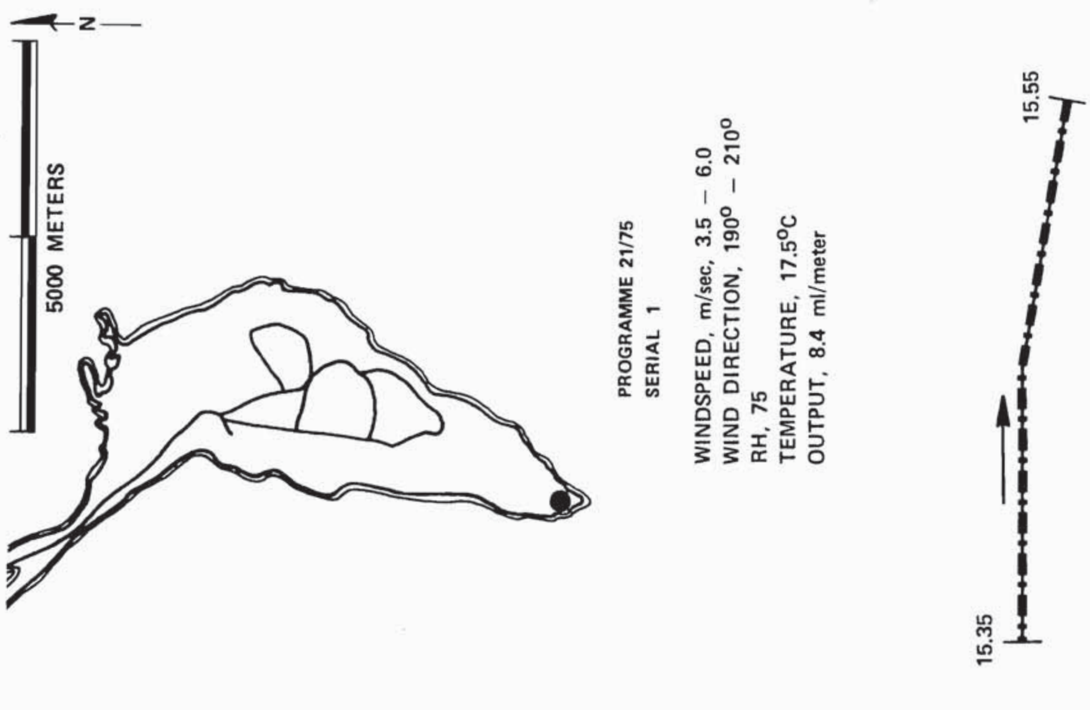

Figure B-1 (C). Challenge 1 — 29 September 1975 (U)

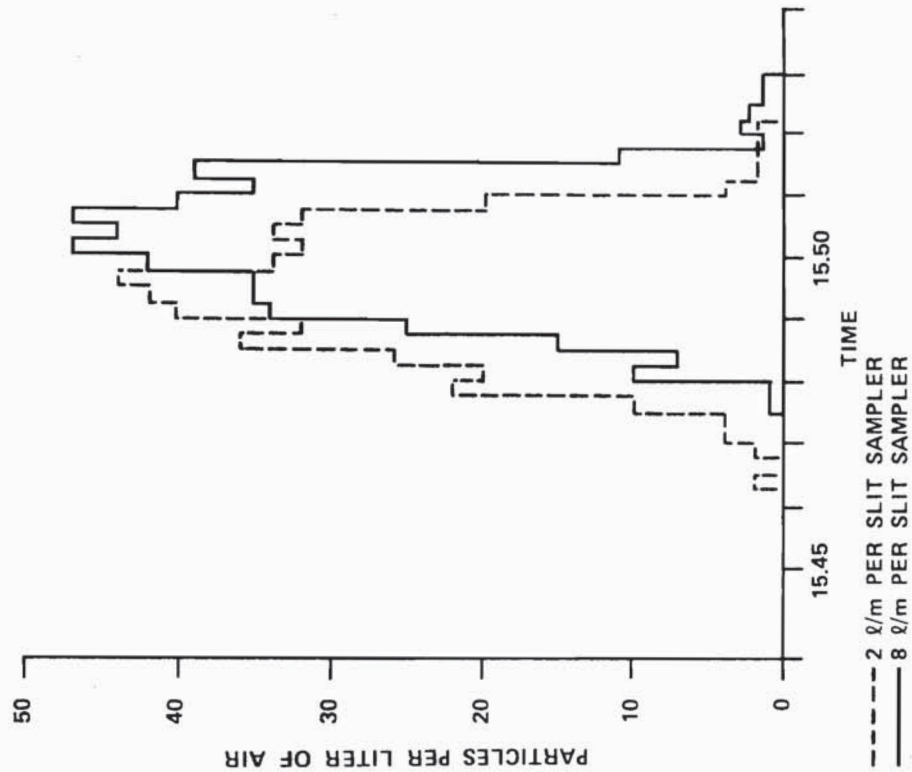

Figure B-2 (C). Challenge 1 — 29 September 1975 (U)

Table B-2 ~~(C)~~

PROGRAMME 21/75 SERIAL 2 DATE 30 Sept. 75 CHALLENGE 2

MATERIAL SPRAYED ISM/BG TIME SPRAYED 12.19 to 12.40 VOLUME SPRAYED 60 litres

LENGTH OF SPRAY LINE 5840 m. RANGE TO SAMPLING SITE 4260 to 5000 m

MEAN WIND SPEED 6.0 to 10.0 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	288	96	1263	129
CASCADE IMP	–	–	406	120
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	114	14		
2 L/MIN			32	16
TIME OF CLOUD ARRIVAL	12.32¾		12.32¾	
TIME OF CLOUD DEPARTURE	12.35¼		12.34½	
TIME CLOUD PRESENT (MINUTES)	2½		1¾	
MEAN CELLS/LITRE				
CYCLONE	38		74	
CASCADE IMP	–		69	
MEAN PARTICLES/LITRE	5.6		9.1	
PEAK PARTICLES/LITRE	15		16	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	6.8		8.1	
CASCADE IMP/SLIT SAMPLER	–		7.6	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			15	
2			53	
3			23	
4			9	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	130	253
CASCADE IMP	–	236
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	23	28
CASCADE IMP/SLIT SAMPLER	–	26

SUSPENSION VIABLE BG 0.93×10^{10}/ml

ESTIMATED SM 2.25×10^{10}/ml

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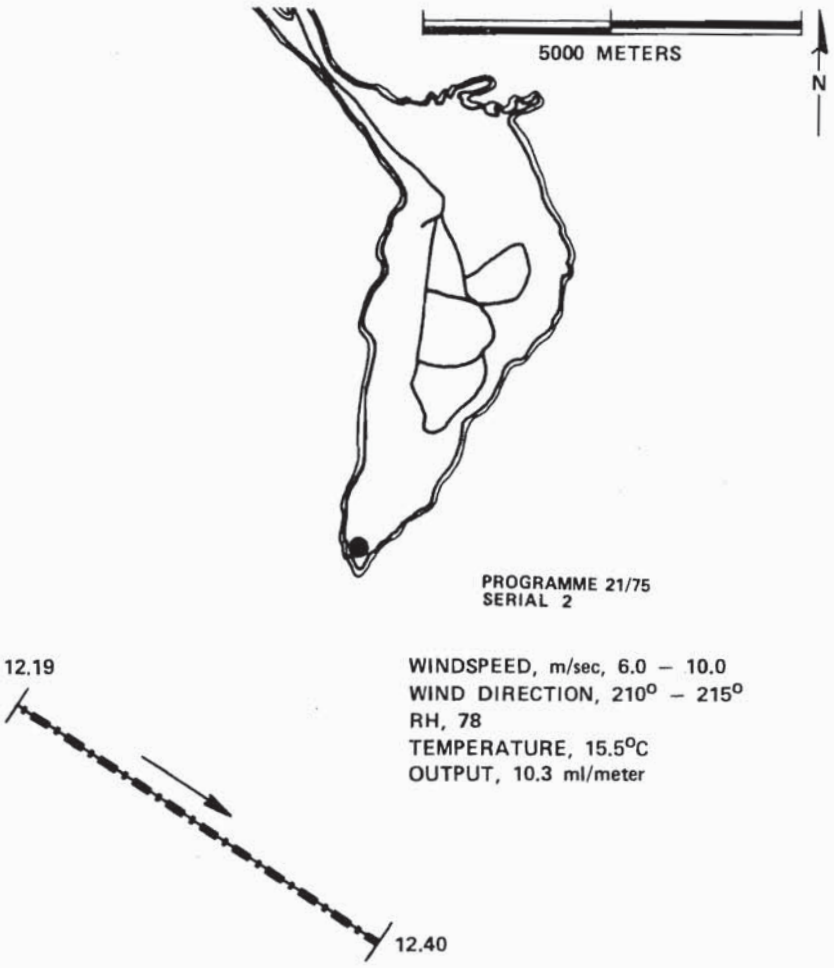

Figure B-3 ~~(C)~~. Challenge 2 – 30 September 1975 (U)

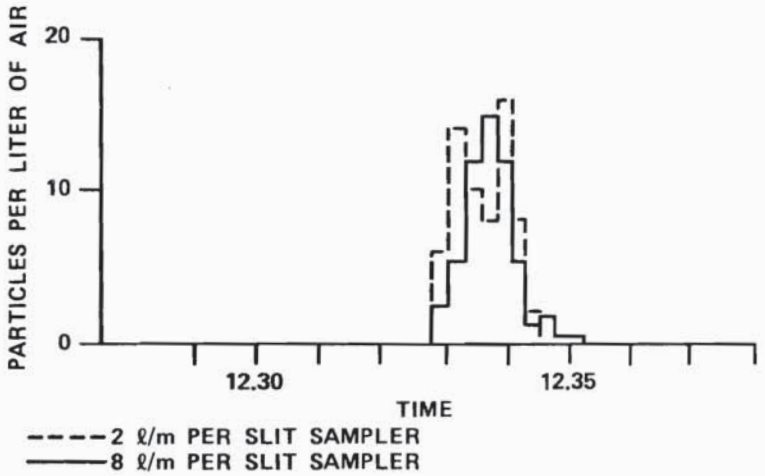

Figure B-4 ~~(C)~~. Challenge 2 – 30 September 1975 (U)

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Table B-3 ~~(C)~~

PROGRAMME 21/75 SERIAL 2 DATE 30 Sept. 75 CHALLENGE 3

MATERIAL SPRAYED ISM/BG TIME SPRAYED 13.03 to 13.23 VOLUME SPRAYED 60 litres

LENGTH OF SPRAY LINE 4730 m. RANGE TO SAMPLING SITE 3340 to 5000 m

MEAN WIND SPEED 6.0 to 10.0 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	633	217	2545	237
CASCADE IMP	–	–	634	187
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	242	30		
2 L/MIN			42	21
TIME OF CLOUD ARRIVAL	13.26¼		13.26½	
TIME OF CLOUD DEPARTURE	13.28¾		13.28¼	
TIME CLOUD PRESENT (MINUTES)	2½		1¾	
MEAN CELLS/LITRE				
CYCLONE	87		135	
CASCADE IMP	–		107	
MEAN PARTICLES/LITRE	12		12	
PEAK PARTICLES/LITRE	29		24	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	7.3		11	
CASCADE IMP/SLIT SAMPLER	–		8.9	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			21	
2			39	
3			32	
4			8	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	298	462
CASCADE IMP		366
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	25	38
CASCADE IMP/SLIT SAMPLER	–	30

SUSPENSION VIABLE BG 0.82×10^{10}/ml

ESTIMATED SM 1.98×10^{10}/ml

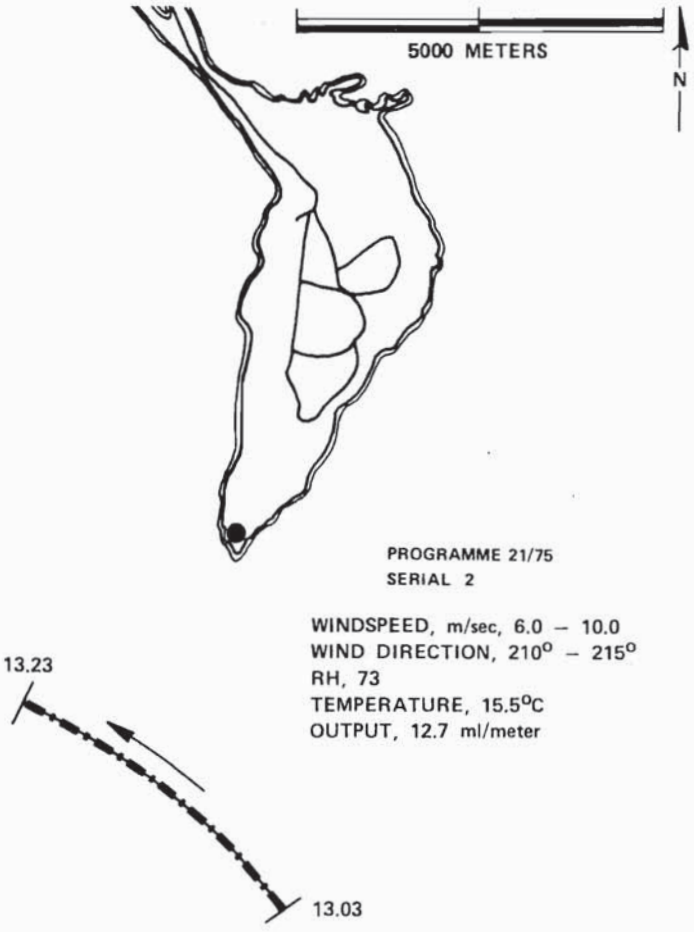

Figure B-5 ~~(C)~~ Challenge 3 – 30 September 1975 (U)

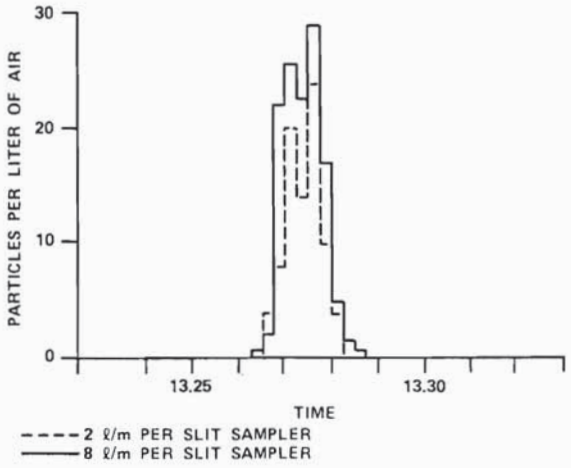

Figure B-6 ~~(C)~~ Challenge 3 – 30 September 1975 (U)

Table B-4 ~~(C)~~

PROGRAMME 21/75 SERIAL 2 DATE 30 Sept. 75 CHALLENGE 4

MATERIAL SPRAYED ISM/BG TIME SPRAYED 13.55 to 14.16 VOLUME SPRAYED 60 litres

LENGTH OF SPRAY LINE 5560 m. RANGE TO SAMPLING SITE 5000 to 5930 m

MEAN WIND SPEED 8.0 to 10.0 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	450	108	2425	165
CASCADE IMP	579	170	530	156
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	203	25		
2 L/MIN			38	19
TIME OF CLOUD ARRIVAL	14.11½		14.12	
TIME OF CLOUD DEPARTURE	14.14		14.14	
TIME CLOUD PRESENT (MINUTES)	2½		2	
MEAN CELLS/LITRE				
CYCLONE	43		83	
CASCADE IMP	68		78	
MEAN PARTICLES/LITRE	10		9.5	
PEAK PARTICLES/LITRE	20		24	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	4.3		8.7	
CASCADE IMP/SLIT SAMPLER	6.8		8.2	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	19		33	
2	52		34	
3	24		29	
4	5		4	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	147	284
CASCADE IMP	233	267
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	15	30
CASCADE IMP/SLIT SAMPLER	23	28

SUSPENSION VIABLE BG 0.91×10^{10}/ml

ESTIMATED SM 2.20×10^{10}/ml

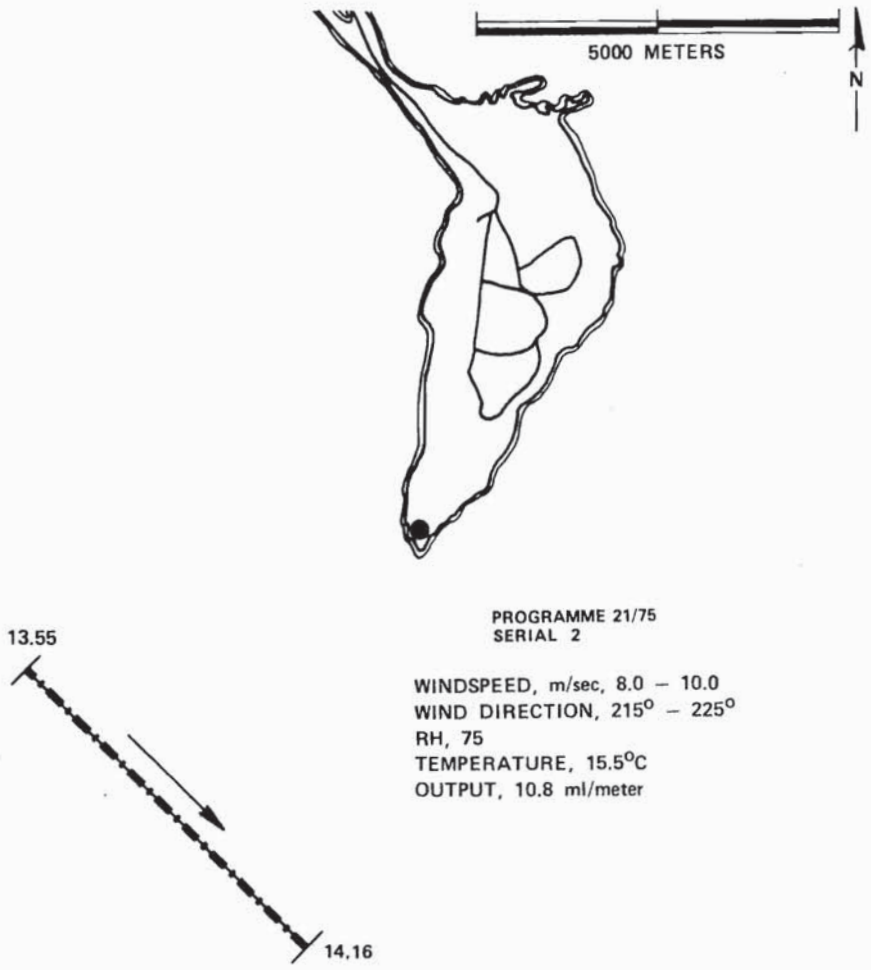

Figure B-7 ~~(C)~~ Challenge 4 – 30 September 1975 (U)

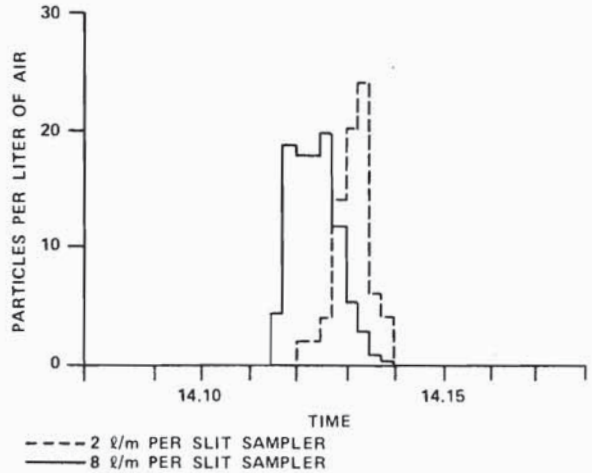

Figure B-8 ~~(C)~~ Challenge 4 – 30 September 1975 (U)

Table B-5 ~~(C)~~

PROGRAMME 21/75 SERIAL 3 DATE 1 Oct. 75 CHALLENGE 5

MATERIAL SPRAYED ISM/BG TIME SPRAYED 14.35 to 15.16 VOLUME SPRAYED 120 litres

LENGTH OF SPRAY LINE 12230 m. RANGE TO SAMPLING SITE 11300 to 13900 m

MEAN WIND SPEED 4.0 to 6.0 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

RED BLUE

	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	578	29	770	32
CASCADE IMP	–	–	106	23
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	44	5.5		
2 L/MIN			7	
TIME OF CLOUD ARRIVAL	15.05¼			
TIME OF CLOUD DEPARTURE	15.09¼			
TIME CLOUD PRESENT (MINUTES)	4		4	
MEAN CELLS/LITRE				
CYCLONE	7.3		8	
CASCADE IMP	–		5.8	
MEAN PARTICLES/LITRE	1.4		–	
PEAK PARTICLES/LITRE	4		–	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	5.2		–	
CASCADE IMP/SLIT SAMPLER	–		–	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			12	
2			43	
3			31	
4			14	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	25	27
CASCADE IMP	–	20
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	18	–
CASCADE IMP/SLIT SAMPLER	–	–

SUSPENSION VIABLE BG 0.87×10^{10}/ml

ESTIMATED SM 2.11×10^{10}/ml

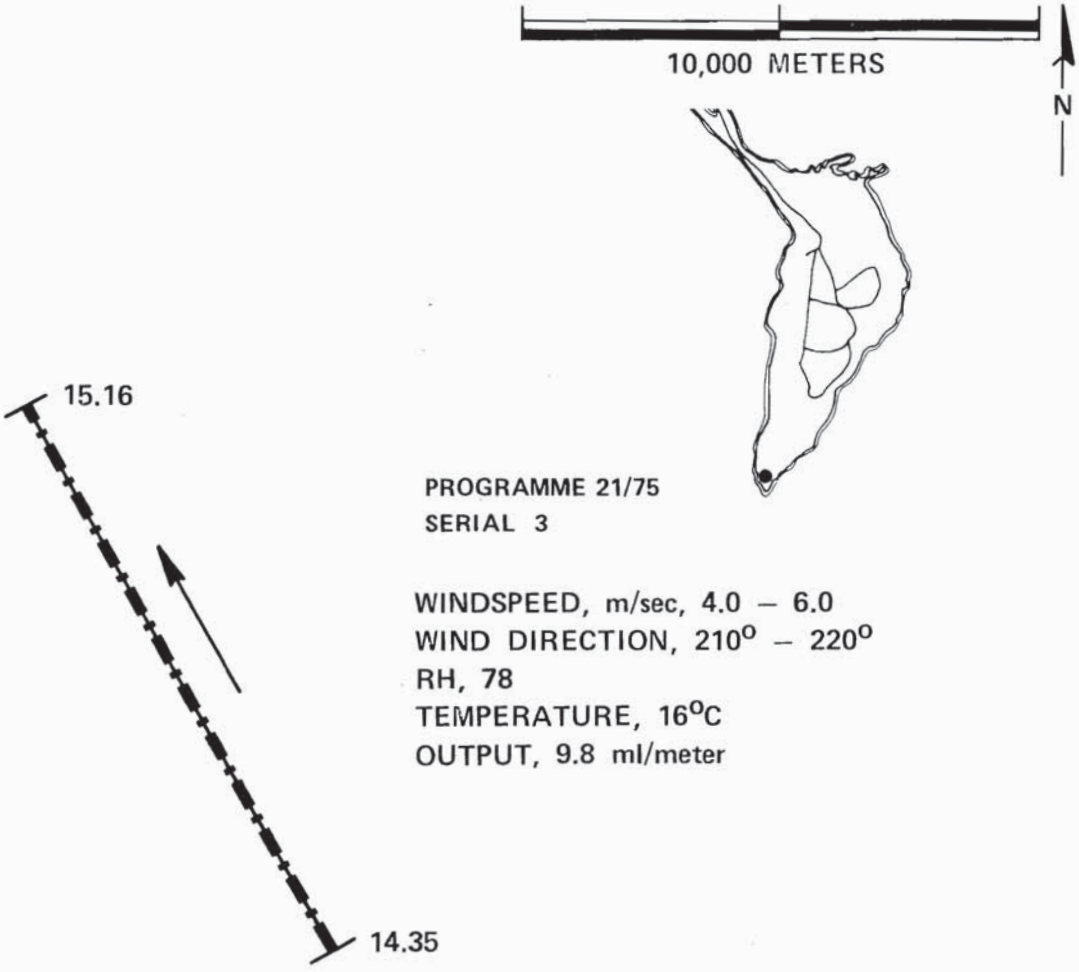

Figure B-9 ~~(C)~~. Challenge 5 – 1 October 1975 (U)

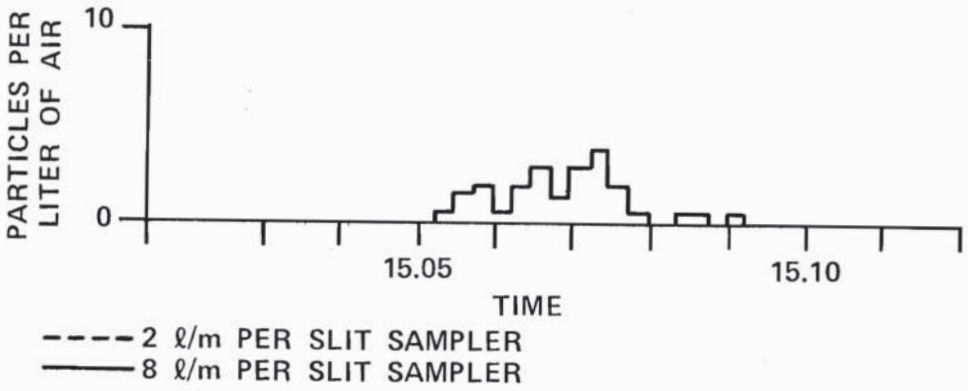

Figure B-10 ~~(C)~~. Challenge 5 – 1 October 1975 (U)

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Table B-6 ~~(C)~~

PROGRAMME 21/75 SERIAL 3 DATE 1 Oct. 75 CHALLENGE 6

MATERIAL SPRAYED ISM/BG TIME SPRAYED 15.40 to 16.21 VOLUME SPRAYED 120 litres

LENGTH OF SPRAY LINE 13160 m. RANGE TO SAMPLING SITE 11120 to 14450 m

MEAN WIND SPEED 4 to 8 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

RED BLUE

	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	812	33	1025	45
CASCADE IMP	–	–	98	18
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	54	6.8		
2 L/MIN			7	
TIME OF CLOUD ARRIVAL	16.31			
TIME OF CLOUD DEPARTURE	16.33½			
TIME CLOUD PRESENT (MINUTES)	2½		2½	
MEAN CELLS/LITRE				
CYCLONE	13		18	
CASCADE IMP	–		7.2	
MEAN PARTICLES/LITRE	2.7		–	
PEAK PARTICLES/LITRE	7.5		–	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	4.8		–	
CASCADE IMP/SLIT SAMPLER	–		–	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			14	
2			40	
3			40	
4			6	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	44	62
CASCADE IMP		25
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	16	
CASCADE IMP/SLIT SAMPLER		

SUSPENSION VIABLE BG 0.91×10^{10}/ml

ESTIMATED SM 2.20×10^{10}/ml

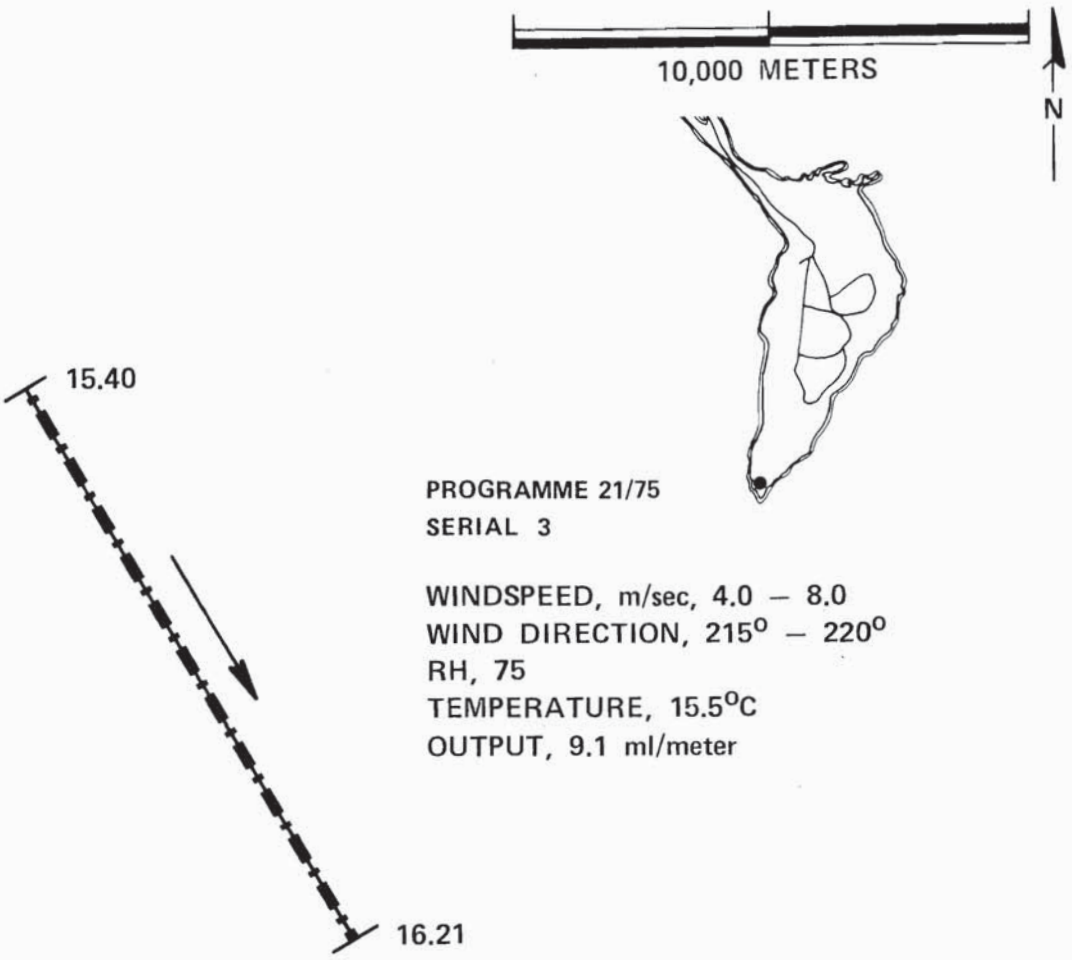

Figure B-11 ~~(C)~~. Challenge 6 – 1 October 1975 (U)

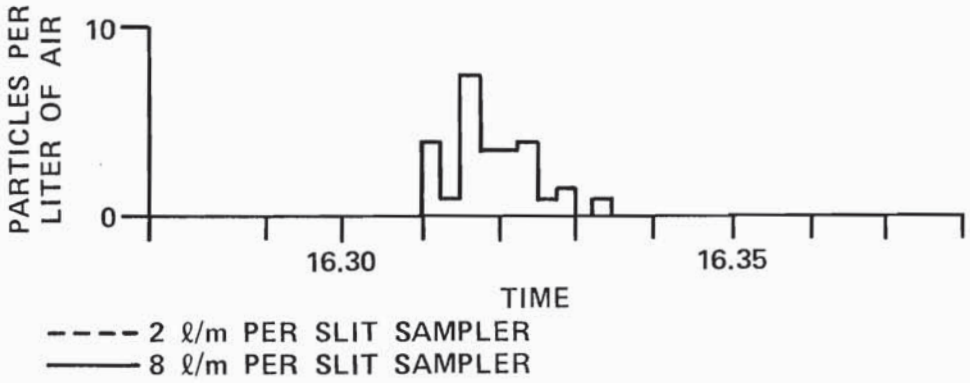

Figure B-12 ~~(C)~~. Challenge 6 – 1 October 1975 (U)

Table B-7 ~~(C)~~

PROGRAMME 21/75 SERIAL 3 DATE 1 Oct. 75 CHALLENGE 7

MATERIAL SPRAYED ISM/BG TIME SPRAYED 17.10 to 17.52 VOLUME SPRAYED 120 litres

LENGTH OF SPRAY LINE 11120 m. RANGE TO SAMPLING SITE 11120 to 12600 m

MEAN WIND SPEED 6 to 8 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	1728	55	1590	56
CASCADE IMP	–	–	169	41
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	91	11		
2 L/MIN			23	12
TIME OF CLOUD ARRIVAL	17.52¾		17.52¼	
TIME OF CLOUD DEPARTURE	17.57		17.55½	
TIME CLOUD PRESENT (MINUTES)	4¼		3¼	
MEAN CELLS/LITRE				
CYCLONE	13		17	
CASCADE IMP	–		13	
MEAN PARTICLES/LITRE	2.6		3.7	
PEAK PARTICLES/LITRE	7.5		18	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	5.0		4.6	
CASCADE IMP/SLIT SAMPLER	–		3.5	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			9	
2			40	
3			35	
4			16	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	44	58
CASCADE IMP	–	44
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	17	16
CASCADE IMP/SLIT SAMPLER	–	12

SUSPENSION VIABLE BG 0.68×10^{10}/ml

ESTIMATED SM 1.65×10^{10}/ml

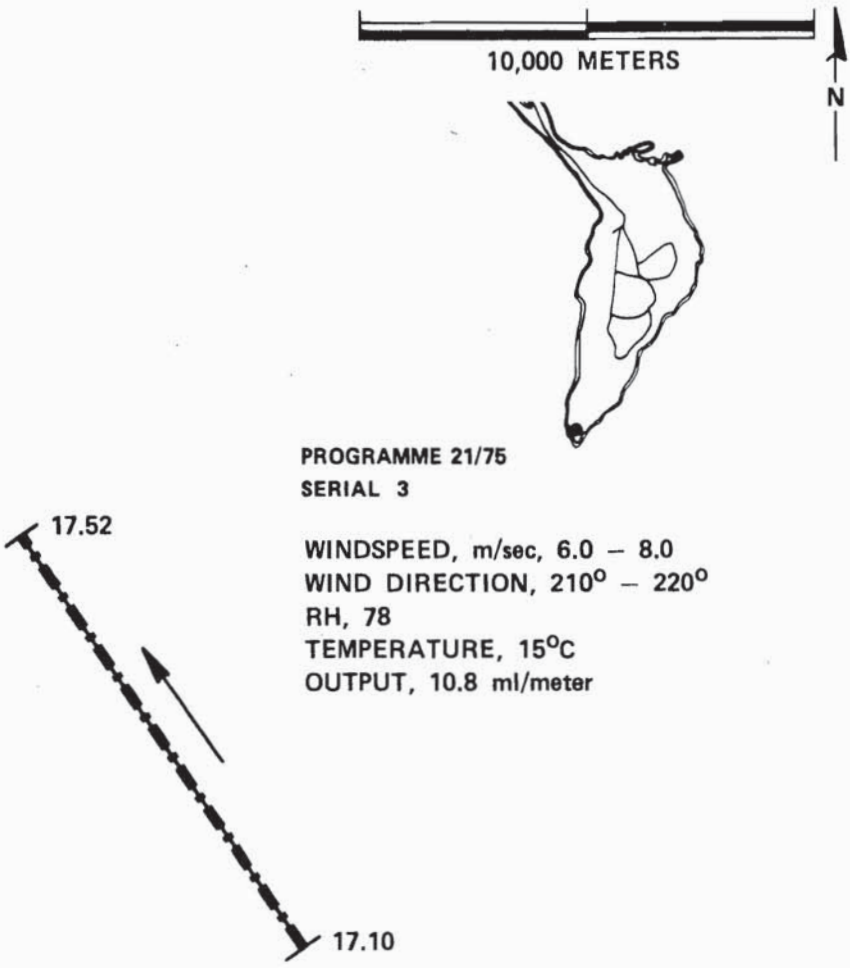

Figure B-13 ~~(C)~~ Challenge 7 – 1 October 1975 (U)

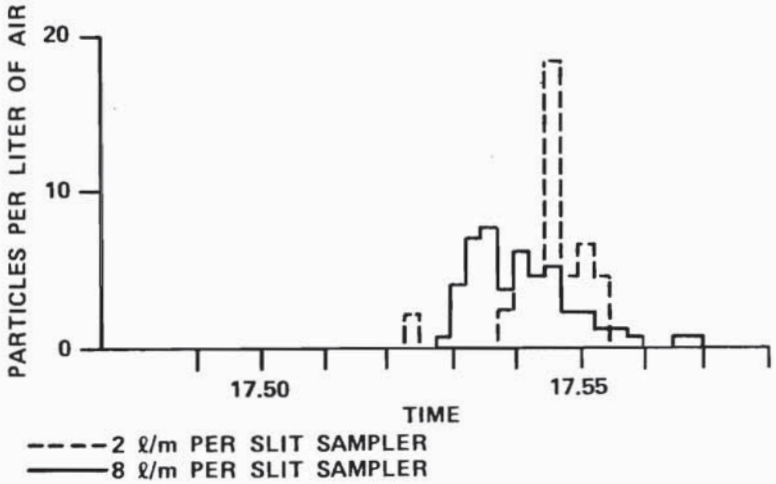

Figure B-14 ~~(C)~~ Challenge 7 – 1 October 1975 (U)

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Table B-8 ~~(C)~~

PROGRAMME 21/75 SERIAL 4 DATE 3 Oct. 75 CHALLENGE 8

MATERIAL SPRAYED ISM/BG TIME SPRAYED 14.07 to 14.27 VOLUME SPRAYED 60 litres

LENGTH OF SPRAY LINE 6670 m. RANGE TO SAMPLING SITE 6490 to 8620 m

MEAN WIND SPEED 6 to 10 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2063	59	2309	44
CASCADE IMP	132	78	–	–
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	93	12		
2 L/MIN			14	7
TIME OF CLOUD ARRIVAL	14.28½		14.28½	
TIME OF CLOUD DEPARTURE	14.30¾		14.29½	
TIME CLOUD PRESENT (MINUTES)	2¼		1	
MEAN CELLS/LITRE				
CYCLONE	26		44	
CASCADE IMP	35		–	
MEAN PARTICLES/LITRE	5.3		7.0	
PEAK PARTICLES/LITRE	13		14	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	4.9		6.3	
CASCADE IMP/SLIT SAMPLER	6.6		–	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			9	
2			62	
3			26	
4			3	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	89	150
CASCADE IMP	120	–
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	17	22
CASCADE IMP/SLIT SAMPLER	23	–

SUSPENSION VIABLE BG 0.60×10^{10}/ml

ESTIMATED SM 1.45×10^{10}/ml

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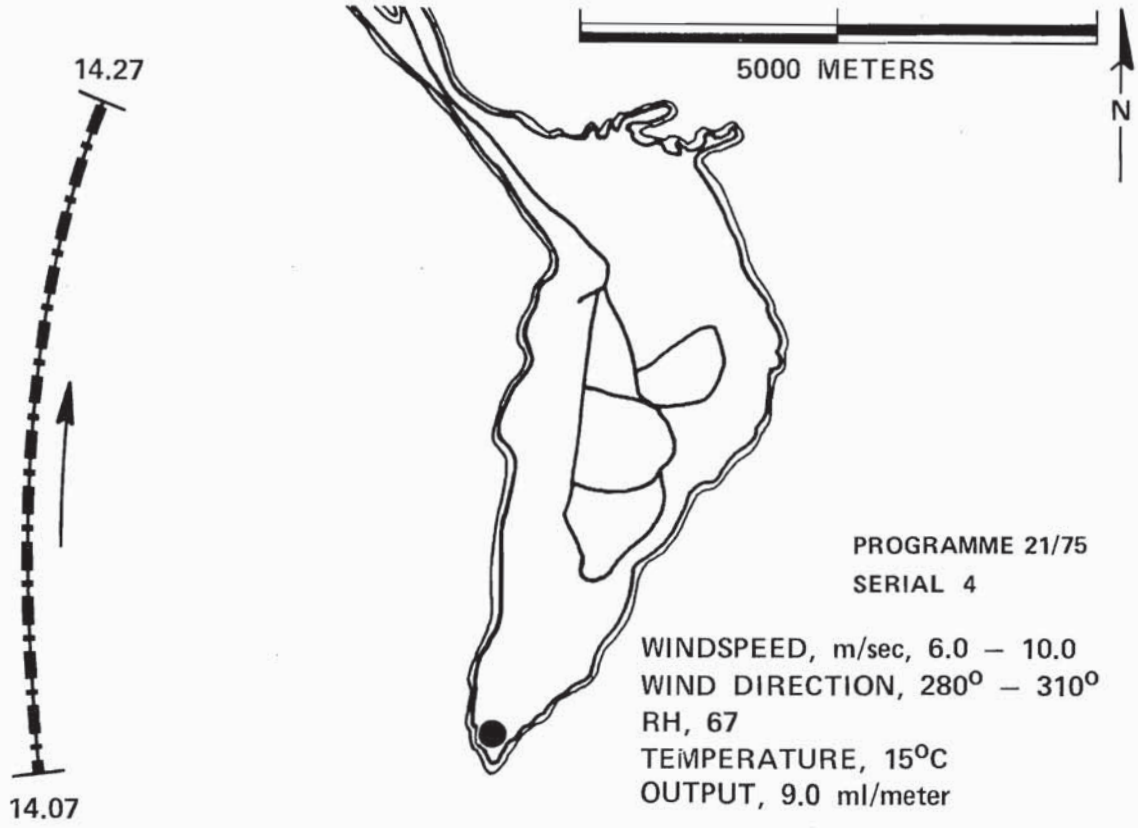

Figure B-15 ~~(C)~~. Challenge 8 – 3 October 1975 (U)

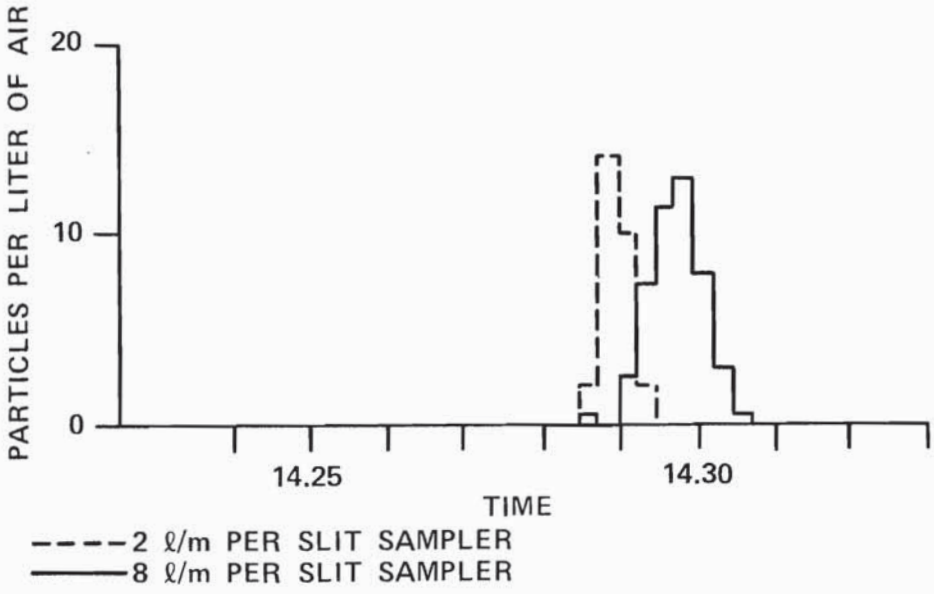

Figure B-16 ~~(C)~~. Challenge 8 – 3 October 1975 (U)

Table B-9 ~~(C)~~

PROGRAMME 21/75 SERIAL 4 DATE 3 Oct. 75 CHALLENGE 9

MATERIAL SPRAYED ISM/BG TIME SPRAYED 15.44 to 16.12 VOLUME SPRAYED 110 litres

LENGTH OF SPRAY LINE 6300 m. RANGE TO SAMPLING SITE 2410 to 7320 m

MEAN WIND SPEED 6 to 9 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2489	1098	3265	916
CASCADE IMP	845	860	776	699
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	602	75		
2 L/MIN			87	44
TIME OF CLOUD ARRIVAL	16.02		16.03	
TIME OF CLOUD DEPARTURE	16.04½		16.04½	
TIME CLOUD PRESENT (MINUTES)	2½		1½	
MEAN CELLS/LITRE				
CYCLONE	439		611	
CASCADE IMP	344		466	
MEAN PARTICLES/LITRE	30		29	
PEAK PARTICLES/LITRE	99		56	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	14.6		21.1	
CASCADE IMP/SLIT SAMPLER	11.5		16.1	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	24		35	
2	46		43	
3	22		16	
4	8		6	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	1501	2090
CASCADE IMP	1176	1594
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	50	72
CASCADE IMP/SLIT SAMPLER	39	55

SUSPENSION VIABLE BG 0.62×10^{10}/ml

ESTIMATED SM 1.50×10^{10}/ml

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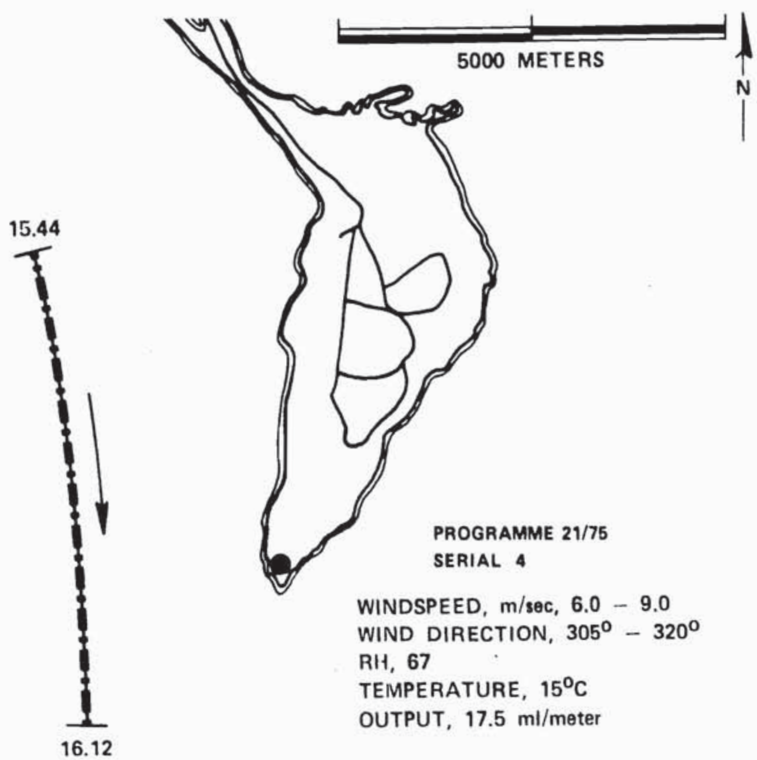

Figure B-17 (C). Challenge 9 – 3 October 1975 (U)

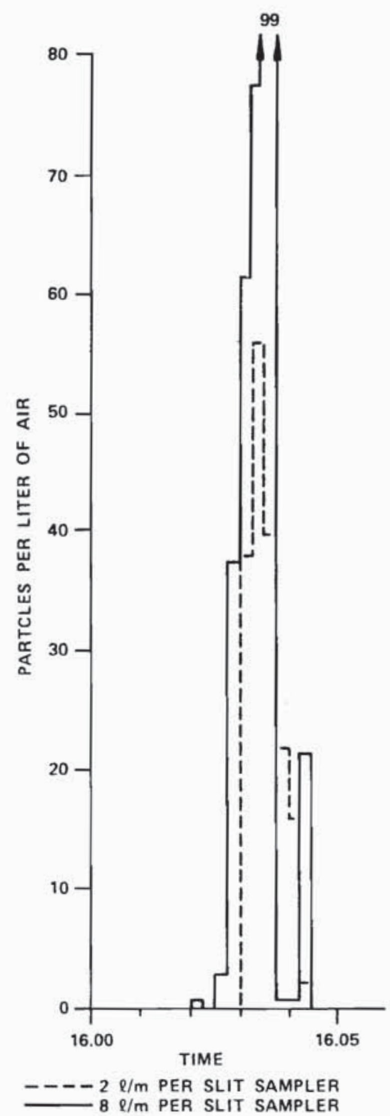

Figure B-18 (C). Challenge 9 – 3 October 1975 (U)

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UNCLASSIFED

Table B-10 ~~(C)~~

PROGRAMME 21/75 SERIAL 4 DATE 3 Oct. 75 CHALLENGE 10

MATERIAL SPRAYED ISM/BG TIME SPRAYED 16.35 to 17.17 VOLUME SPRAYED 120 litres

LENGTH OF SPRAY LINE 7040 m. RANGE TO SAMPLING SITE 3060 to 6120 m

MEAN WIND SPEED 5 to 10 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2946	506	3111	437
CASCADE IMP	628	369	503	296
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	475	59		
2 L/MIN			47	24
TIME OF CLOUD ARRIVAL	17.10		17.16	
TIME OF CLOUD DEPARTURE	17.40¼		17.39	
TIME CLOUD PRESENT (MINUTES)	Positive for 13¾ mins		Positive for 5½ mins	
MEAN CELLS/LITRE				
CYCLONE	37		79	
CASCADE IMP	27		54	
MEAN PARTICLES/LITRE	4.3		4.4	
PEAK PARTICLES/LITRE	19		10	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	8.6		18	
CASCADE IMP/SLIT SAMPLER	6.3		12	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	25		18	
2	42		49	
3	25		32	
4	8		1	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	127	270
CASCADE IMP	92	185
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	29	62
CASCADE IMP/SLIT SAMPLER	22	41

SUSPENSION VIABLE BG 0.58×10^{10}/ml

ESTIMATED SM 1.40×10^{10}/ml

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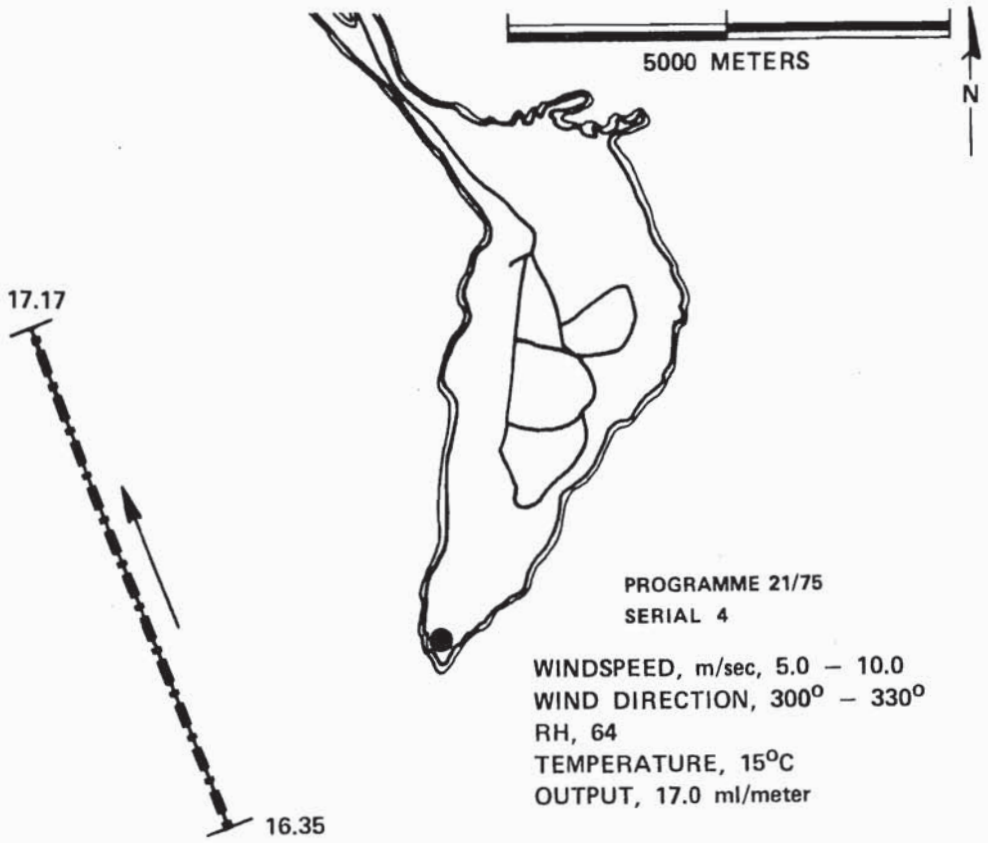

Figure B-19 ~~(C)~~ Challenge 10 – 3 October 1975 (U)

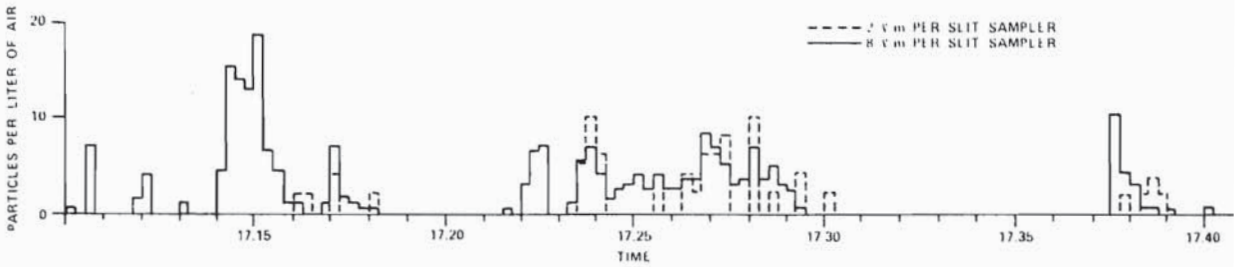

Figure B-20 ~~(C)~~ Challenge 10 – 3 October 1975 (U)

~~CONFIDENTIAL~~

Table B-11 ~~(C)~~

PROGRAMME 21/75 SERIAL 5 DATE 6 Oct. 75 CHALLENGE 11

MATERIAL SPRAYED ISM/BG TIME SPRAYED 13.10 to 14.13 VOLUME SPRAYED 240 litres

LENGTH OF SPRAY LINE 20200 m. RANGE TO SAMPLING SITE 21680 to 26680 m

MEAN WIND SPEED 3 to 5 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2688	274	2834	249
CASCADE IMP	556	327	440	259
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	350	44		
2 L/MIN			64	32
TIME OF CLOUD ARRIVAL	14.17¼		14.21¼	
TIME OF CLOUD DEPARTURE	14.34		14.33½	
TIME CLOUD PRESENT (MINUTES)	16¾		12¼	
MEAN CELLS/LITRE				
CYCLONE	16		20	
CASCADE IMP	20		21	
MEAN PARTICLES/LITRE	2.6		2.6	
PEAK PARTICLES/LITRE	13		10	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	6.2		7.7	
CASCADE IMP/SLIT SAMPLER	7.7		8.1	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	33		32	
2	52		45	
3	14		20	
4	1		3	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 3.42

MEAN CELLS/LITRE		
CYCLONE	55	68
CASCADE IMP	68	72
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	21	26
CASCADE IMP/SLIT SAMPLER	26	28

SUSPENSION VIABLE BG 0.66×10^{10}/ml

ESTIMATED SM 1.60×10^{10}/ml

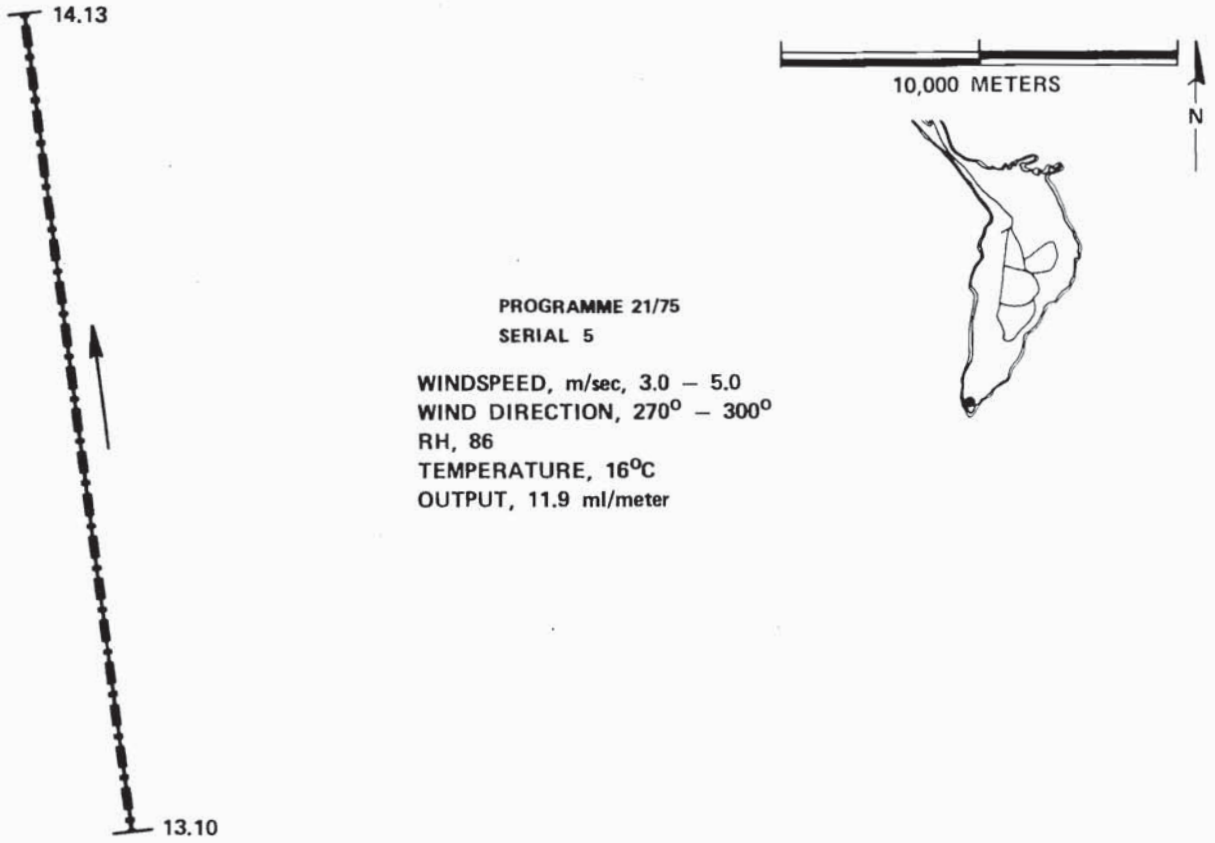

Figure B-21 ~~(C)~~ Challenge 11 – 6 October 1975 (U)

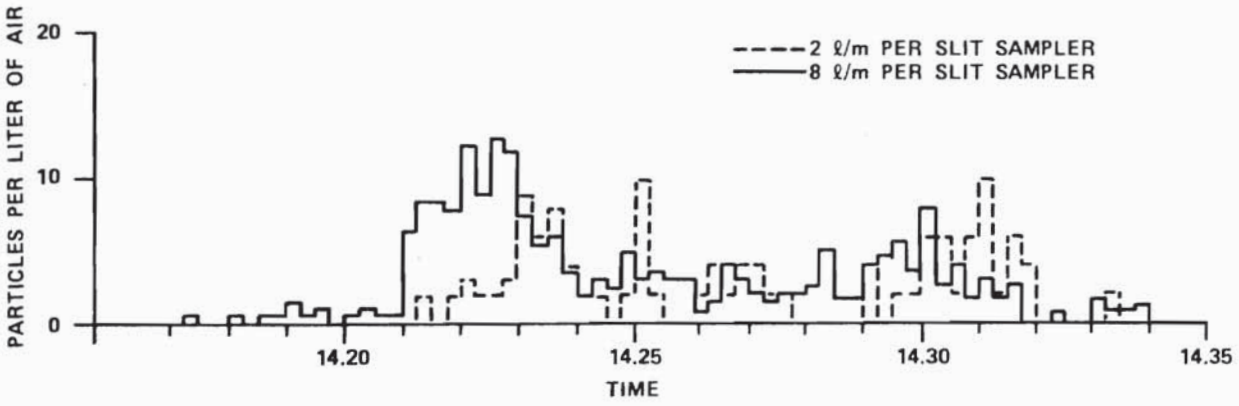

Figure B-22 ~~(C)~~ Challenge 11 – 6 October 1975 (U)

Table B-12 ~~(C)~~

PROGRAMME 21/75 SERIAL 6 DATE 13 Oct. 75 CHALLENGE 12

MATERIAL SPRAYED ISM/BG TIME SPRAYED 22.30 to 22.57 VOLUME SPRAYED 77 litres

LENGTH OF SPRAY LINE 9080 m. RANGE TO SAMPLING SITE 4820 to 7410 m

MEAN WIND SPEED 2 to 3 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2135	157	2106	143
CASCADE IMP	192	113	256	151
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	168	21		
2 L/MIN			35	18
TIME OF CLOUD ARRIVAL	22.58		22.58¾	
TIME OF CLOUD DEPARTURE	23.08½		23.08½	
TIME CLOUD PRESENT (MINUTES)	10½		9¾	
MEAN CELLS/LITRE				
CYCLONE	15		15	
CASCADE IMP	11		15	
MEAN PARTICLES/LITRE	2.0		1.8	
PEAK PARTICLES/LITRE	7.5		8.0	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	7.5		8.3	
CASCADE IMP/SLIT SAMPLER	5.5		8.3	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	16		41	
2	45		40	
3	36		11	
4	3		8	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	84	84
CASCADE IMP	61	84
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	42	46
CASCADE IMP/SLIT SAMPLER	31	46

SUSPENSION VIABLE BG 0.44×10^{10}/ml

ESTIMATED SM 2.02×10^{10}/ml

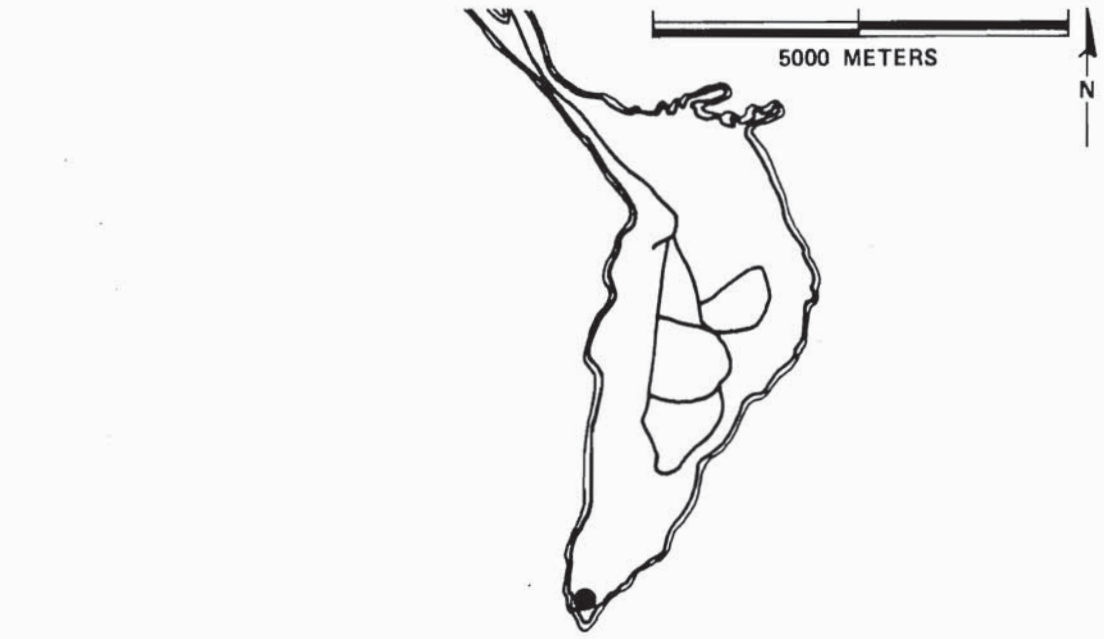

Figure B-23 ~~(C)~~ Challenge 12 – 13 October 1975 (U)

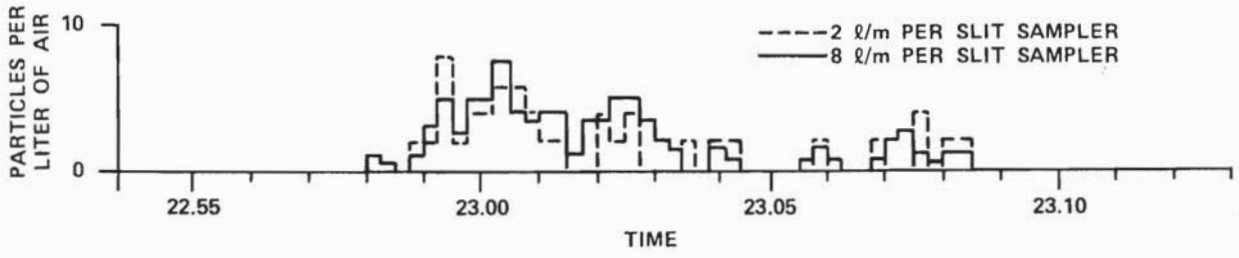

Figure B-24 ~~(C)~~ Challenge 12 – 13 October 1975 (U)

~~CONFIDENTIAL~~

Table B-13 ~~(C)~~

PROGRAMME 21/75 SERIAL 6 DATE 13 Oct. 75 CHALLENGE 13

MATERIAL SPRAYED ISM/BG TIME SPRAYED 23.51 to 00.19 VOLUME SPRAYED 105 litres

LENGTH OF SPRAY LINE 7780 m. RANGE TO SAMPLING SITE 3340 to 5710 m

MEAN WIND SPEED 2 to 3 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	743	4.4	508	3.2
CASCADE IMP	–	–	116	6.0
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	10	1.3		
2 L/MIN			2	
TIME OF CLOUD ARRIVAL	00.14½			
TIME OF CLOUD DEPARTURE	00.15¼			
TIME CLOUD PRESENT (MINUTES)	¾		¾	
MEAN CELLS/LITRE				
CYCLONE	6		2	
CASCADE IMP	–		5	
MEAN PARTICLES/LITRE	1.7		–	
PEAK PARTICLES/LITRE	2.0		–	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	3.5		–	
CASCADE IMP/SLIT SAMPLER	–		–	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1				
2				
3				
4				

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	33	11
CASCADE IMP	–	28
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	20	–
CASCADE IMP/SLIT SAMPLER	–	–

SUSPENSION VIABLE BG 0.52×10^{10}/ml

ESTIMATED SM 2.38×10^{10}/ml

~~CONFIDENTIAL~~

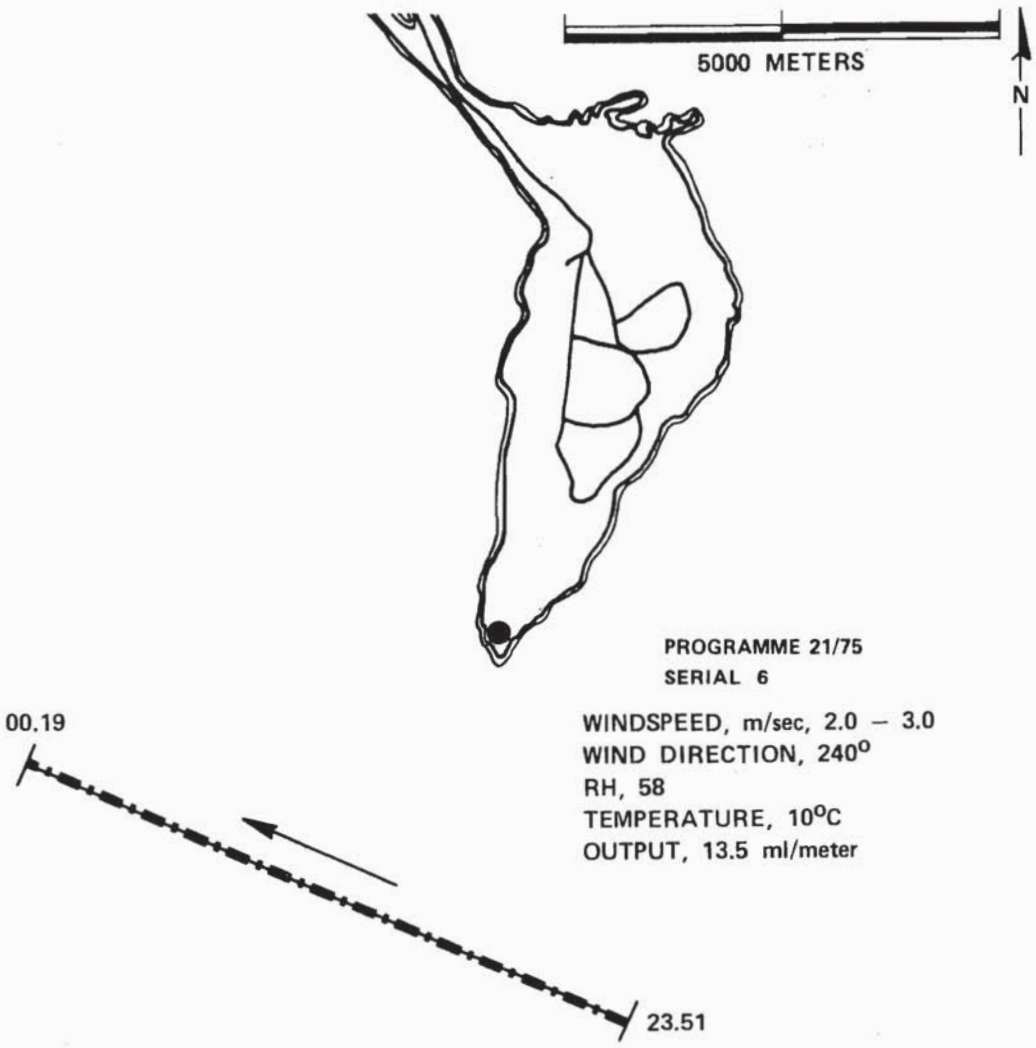

Figure B-25 ~~(C)~~ Challenge 13 – 13 October 1975 (U)

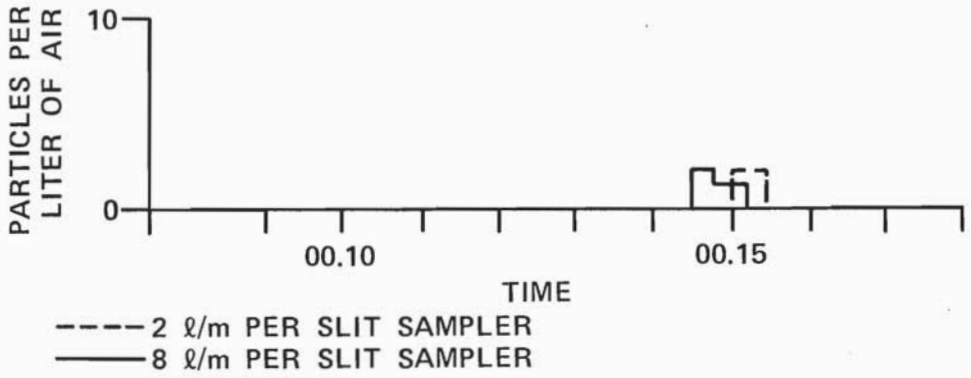

Figure B-26 ~~(C)~~ Challenge 13 – 13 October 1975 (U)

Table B-14 ~~(C)~~

PROGRAMME 21/75 SERIAL 7 DATE 15 Oct. 75 CHALLENGE 14

MATERIAL SPRAYED ISM/BG TIME SPRAYED 18.40 to 19.02 VOLUME SPRAYED 78 litres

LENGTH OF SPRAY LINE 6760 m. RANGE TO SAMPLING SITE 3150 to 7040 m

MEAN WIND SPEED 3 to 8 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

RED BLUE

	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	1483	111	1147	127
CASCADE IMP	303	178	235	138
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	132	17		
2 L/MIN			41	21
TIME OF CLOUD ARRIVAL	19.03		19.03	
TIME OF CLOUD DEPARTURE	19.05¾		19.06	
TIME CLOUD PRESENT (MINUTES)	2¾		3	
MEAN CELLS/LITRE				
CYCLONE	40		42	
CASCADE IMP	65		46	
MEAN PARTICLES/LITRE	6.2		7.0	
PEAK PARTICLES/LITRE	17		26	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	6.5		6.0	
CASCADE IMP/SLIT SAMPLER	10.5		6.6	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	31		28	
2	43		32	
3	20		26	
4	6		14	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	223	234
CASCADE IMP	363	257
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	36	33
CASCADE IMP/SLIT SAMPLER	59	37

SUSPENSION VIABLE BG 0.53×10^{10}/ml

ESTIMATED SM 2.43×10^{10}/ml

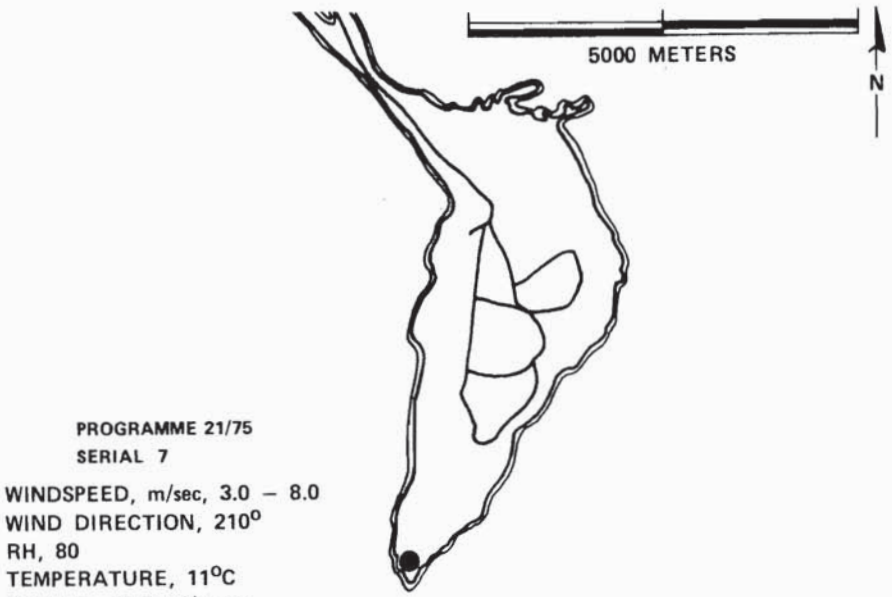

Figure B-27 (C). Challenge 14 – 15 October 1975 (U)

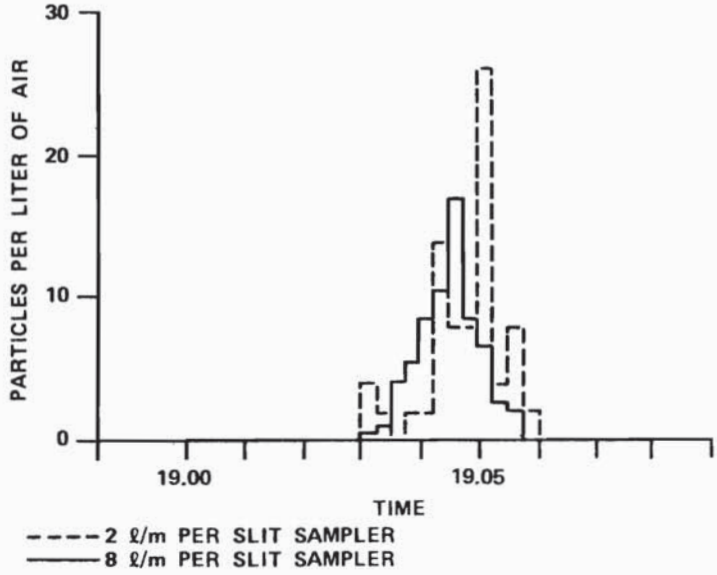

Figure B-28 (C). Challenge 14 – 15 October 1975 (U)

Table B-15 ~~(C)~~

PROGRAMME 21/75 SERIAL 8 DATE 17 Oct. 75 CHALLENGE 15

MATERIAL SPRAYED ISM/BG TIME SPRAYED 12.21 to 12.55 VOLUME SPRAYED 132 litres

LENGTH OF SPRAY LINE 5870 m. RANGE TO SAMPLING SITE 2500 to 5190 m

MEAN WIND SPEED 3 to 6 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2655	1139	2854	1031
CASCADE IMP	871	1105	1417	834
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	TNTC	–		
2 L/MIN			183	92
TIME OF CLOUD ARRIVAL	12.47¼		12.47	
TIME OF CLOUD DEPARTURE	12.52½		12.51½	
TIME CLOUD PRESENT (MINUTES)	5¼		4½	
MEAN CELLS/LITRE				
CYCLONE	217		229	
CASCADE IMP	210		185	
MEAN PARTICLES/LITRE	–		20	
PEAK PARTICLES/LITRE	–		48	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	–		11.5	
CASCADE IMP/SLIT SAMPLER	–		9.3	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	24		29	
2	59		52	
3	14		16	
4	3		3	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	1211	1278
CASCADE IMP	1172	1032
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	–	64
CASCADE IMP/SLIT SAMPLER	–	52

SUSPENSION VIABLE BG 0.51×10^{10}/ml

ESTIMATED SM 2.34×10^{10}/ml

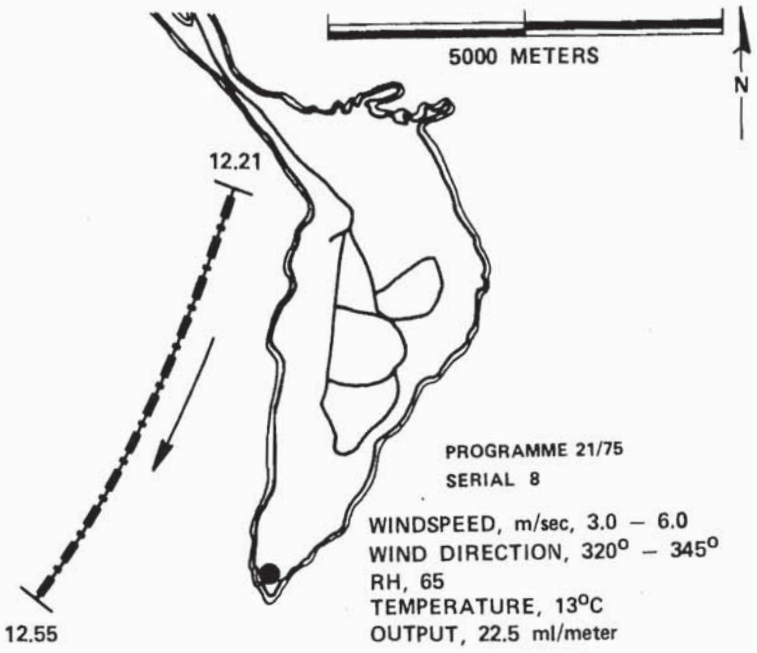

Figure B-29 ~~(C)~~. Challenge 15 – 17 October 1975 (U)

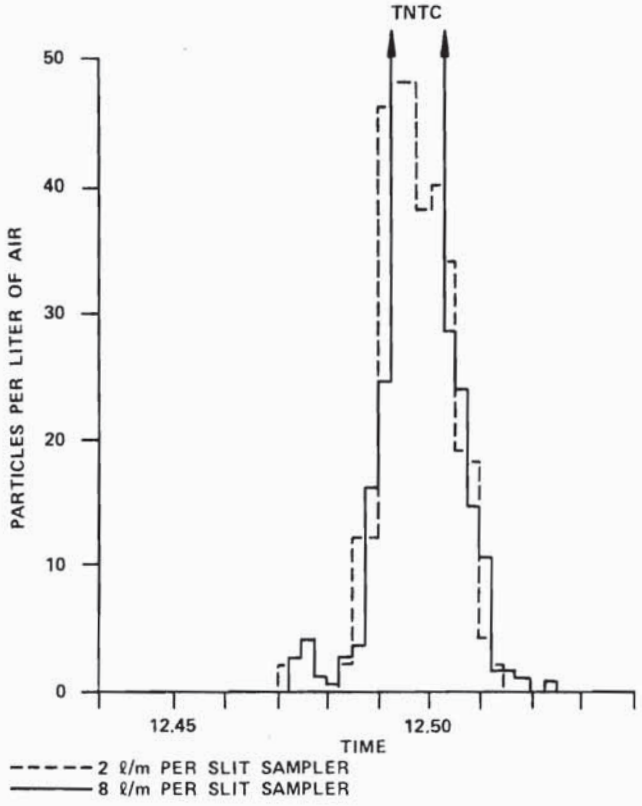

Figure B-30 ~~(C)~~. Challenge 15 – 17 October 1975 (U)

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Table B-16 ~~(C)~~

PROGRAMME 21/75 SERIAL 8 DATE 17 Oct. 75 CHALLENGE 16

MATERIAL SPRAYED ISM/BG TIME SPRAYED 13.21 to 13.55 VOLUME SPRAYED 134 litres

LENGTH OF SPRAY LINE 6485 m. RANGE TO SAMPLING SITE 4360 to 7410 m

MEAN WIND SPEED 4 to 6 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE CYCLONE CASCADE IMP	ONLY	TRACE	RECOVERIES	
PARTICLE DOSAGE SLIT SAMPLER 8 L/MIN 2 L/MIN		OF	BG	
TIME OF CLOUD ARRIVAL TIME OF CLOUD DEPARTURE TIME CLOUD PRESENT (MINUTES)	WIND SHIFT DURING EMISSION			
MEAN CELLS/LITRE CYCLONE CASCADE IMP				
MEAN PARTICLES/LITRE PEAK PARTICLES/LITRE				
MEAN CELLS/PARTICLE CYCLONE/SLIT SAMPLER CASCADE IMP/SLIT SAMPLER				
DISTRIBUTION OF BG IN CASCADE IMPACTOR % ON STAGE 1 2 3 4				

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE CYCLONE CASCADE IMP		
MEAN CELLS/PARTICLE CYCLONE/SLIT SAMPLER CASCADE IMP/SLIT SAMPLER		

SUSPENSION VIABLE BG 0.58×10^{10}/ml

ESTIMATED SM 2.66×10^{10}/ml

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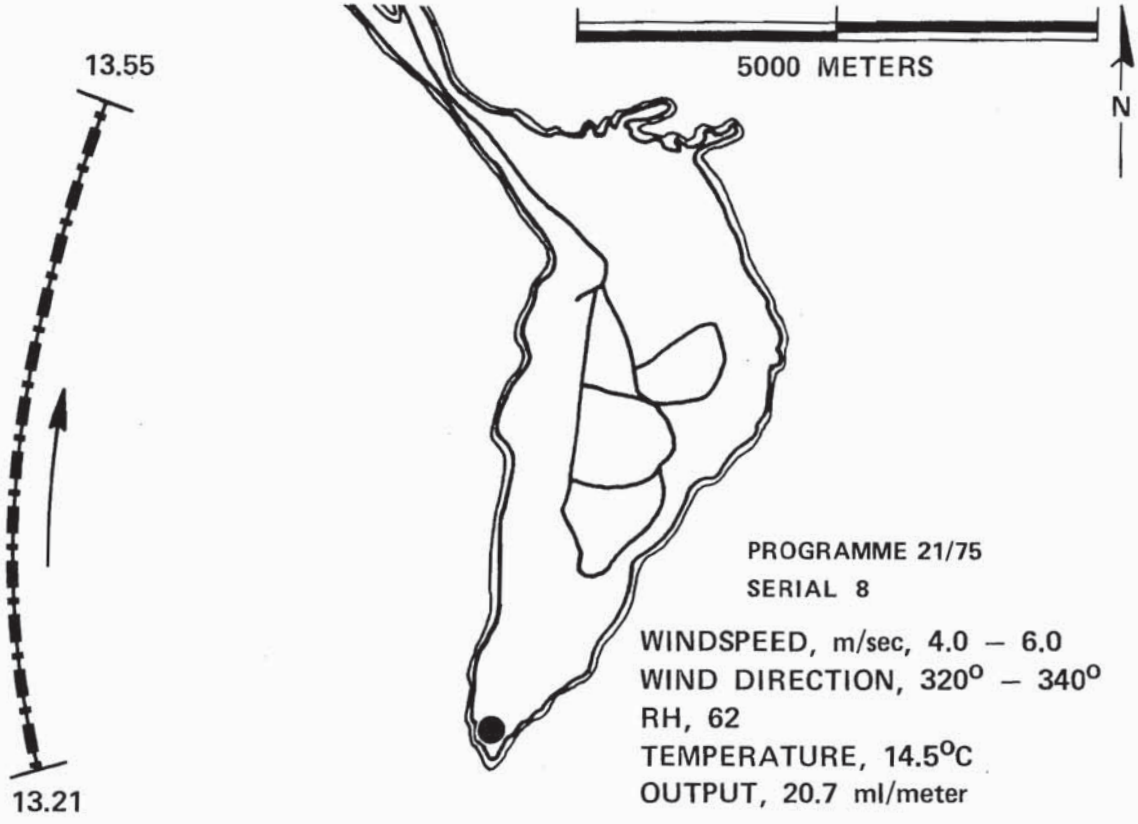

Figure B-31 ~~(C)~~. Challenge 16 – 17 October 1975 (U)

~~CONFIDENTIAL~~

Table B-17 ~~(C)~~

PROGRAMME 21/75 SERIAL 9 DATE 18 Oct. 75 CHALLENGE 17

MATERIAL SPRAYED ISM/BG TIME SPRAYED 16.45 to 17.19 VOLUME SPRAYED 132 litres

LENGTH OF SPRAY LINE 6760 m. RANGE TO SAMPLING SITE 3610 to 7040 m

MEAN WIND SPEED 1 to 2 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

RED BLUE

	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE CYCLONE CASCADE IMP	NO BG RECOVERED			
PARTICLE DOSAGE SLIT SAMPLER 8 L/MIN 2 L/MIN	CLOUD DID NOT REACH SAMPLING SITE DUE TO			
TIME OF CLOUD ARRIVAL TIME OF CLOUD DEPARTURE TIME CLOUD PRESENT (MINUTES)	FALL IN WIND SPEED TO ZERO			
MEAN CELLS/LITRE CYCLONE CASCADE IMP				
MEAN PARTICLES/LITRE PEAK PARTICLES/LITRE				
MEAN CELLS/PARTICLE CYCLONE/SLIT SAMPLER CASCADE IMP/SLIT SAMPLER				
DISTRIBUTION OF BG IN CASCADE IMPACTOR % ON STAGE 1 2 3 4				

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE CYCLONE CASCADE IMP		
MEAN CELLS/PARTICLE CYCLONE/SLIT SAMPLER CASCADE IMP/SLIT SAMPLER		

SUSPENSION VIABLE BG 0.55×10^{10}/ml

ESTIMATED SM 2.52×10^{10}/ml

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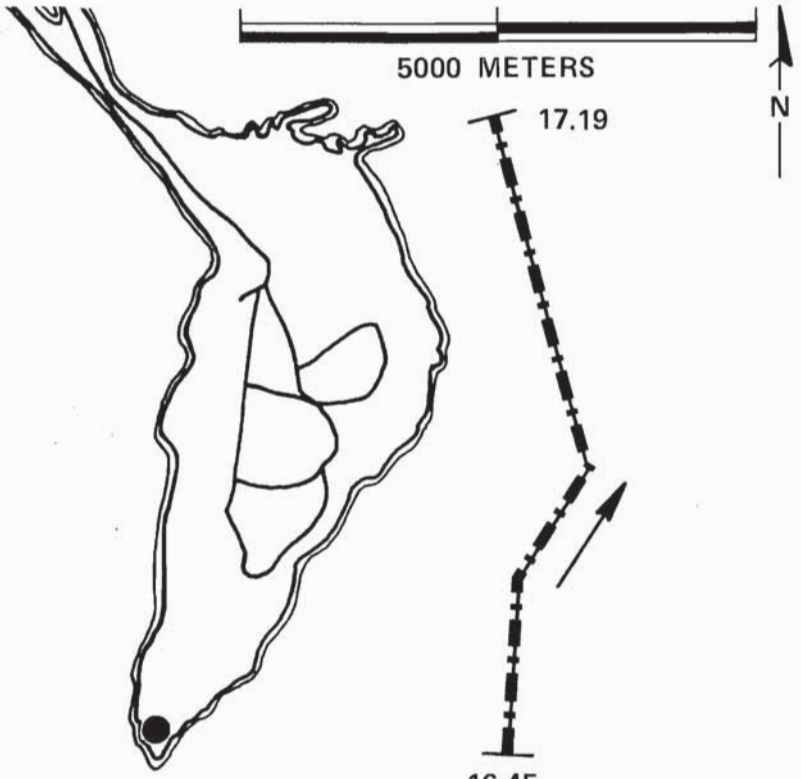

Figure B-32 ~~(C)~~ Challenge 17 – 18 October 1975 (U)

Table B-18 ~~(C)~~

PROGRAMME 21/75 SERIAL 10 DATE 19 Oct. 75 CHALLENGE 18

MATERIAL SPRAYED ISM/BG TIME SPRAYED 18.57 to 19.24 VOLUME SPRAYED 104 litres

LENGTH OF SPRAY LINE 8150 m. RANGE TO SAMPLING SITE 3520 to 6580 m

MEAN WIND SPEED 6 to 9 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

RED BLUE

	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	845	39	676	43
CASCADE IMP	CONTAMINATED		119	70
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	60	7.5		
2 L/MIN			6	
TIME OF CLOUD ARRIVAL	19.09¾			
TIME OF CLOUD DEPARTURE	19.11¼			
TIME CLOUD PRESENT (MINUTES)	1½		1½	
MEAN CELLS/LITRE				
CYCLONE	26		29	
CASCADE IMP	–		47	
MEAN PARTICLES/LITRE	5.0		–	
PEAK PARTICLES/LITRE	9		–	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	5.2		–	
CASCADE IMP/SLIT SAMPLER	–		–	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1			5	
2			70	
3			18	
4			7	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	145	162
CASCADE IMP	–	262
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	28	–
CASCADE IMP/SLIT SAMPLER	–	–

SUSPENSION VIABLE BG 0.71×10^{10}/ml

ESTIMATED SM 3.25×10^{10}/ml

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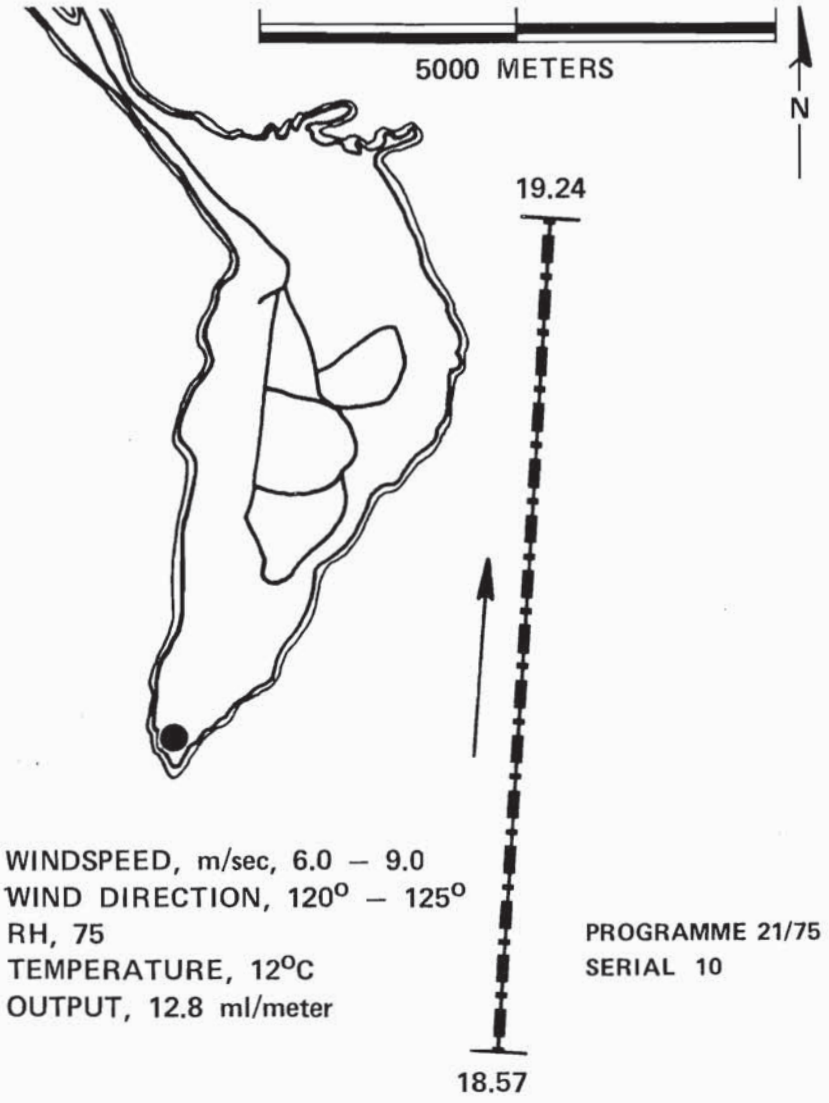

Figure B-33 ~~(C)~~ Challenge 18 – 19 October 1975 (U)

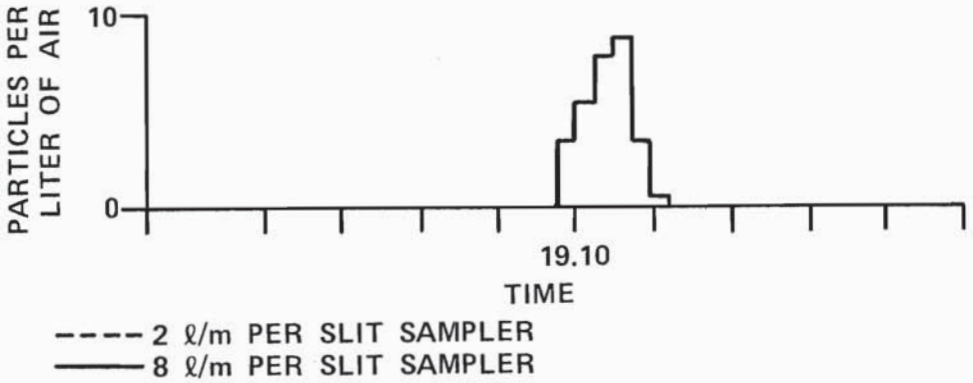

Figure B-34 ~~(C)~~ Challenge 18 – 19 October 1975 (U)

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Table B-19 ~~(C)~~

PROGRAMME 21/75 SERIAL 10 DATE 19 Oct. 75 CHALLENGE 19

MATERIAL SPRAYED ISM/BG TIME SPRAYED 20.16 to 20.37 VOLUME SPRAYED 82 litres

LENGTH OF SPRAY LINE 4540 m. RANGE TO SAMPLING SITE 2000 to 3980 m

MEAN WIND SPEED 7 to 10 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	5401	1383	2217	718
CASCADE IMP	2931	1724	1166	686
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	1432	179	ONE PLATE SPOILT	
2 L/MIN			INCOMPLETE SAMPLE	
TIME OF CLOUD ARRIVAL	20.28			
TIME OF CLOUD DEPARTURE	20.32½			
TIME CLOUD PRESENT (MINUTES)	4½		4½	
MEAN CELLS/LITRE				
CYCLONE	307		160	
CASCADE IMP	383		152	
MEAN PARTICLES/LITRE	40		–	
PEAK PARTICLES/LITRE	70		–	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	7.7		–	
CASCADE IMP/SLIT SAMPLER	9.6		–	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	29		31	
2	49		45	
3	17		18	
4	5		6	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	1713	893
CASCADE IMP	2137	848
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	43	–
CASCADE IMP/SLIT SAMPLER	54	–

SUSPENSION VIABLE BG 0.50×10^{10}/ml

ESTIMATED SM 2.29×10^{10}/ml

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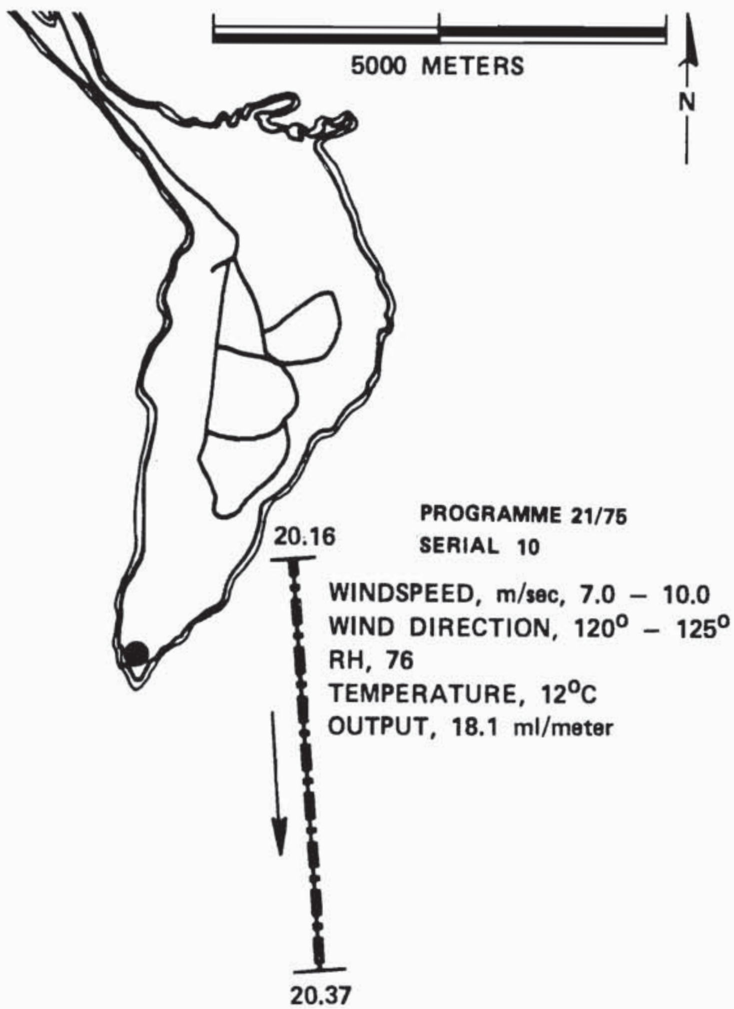

Figure B-35 ~~(C)~~. Challenge 19 – 19 October 1975 (U)

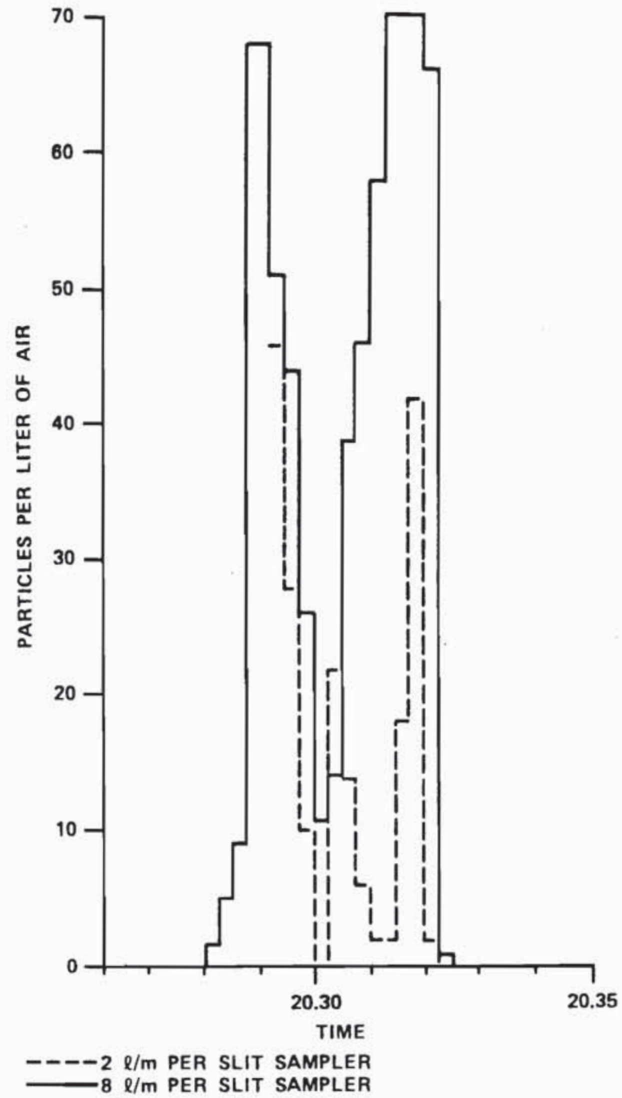

Figure B-36 ~~(C)~~. Challenge 19 – 19 October 1975 (U)

~~CONFIDENTIAL~~

Table B-20 ~~(C)~~

PROGRAMME 21/75 SERIAL 10 DATE 19 Oct. 75 CHALLENGE 20

MATERIAL SPRAYED ISM/BG TIME SPRAYED 21.11 to 21.33 VOLUME SPRAYED 88 litres

LENGTH OF SPRAY LINE 4540 m. RANGE TO SAMPLING SITE 2000 to 3980 m

MEAN WIND SPEED 8 to 10 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	1961	424	1226	328
CASCADE IMP	466	274	544	320
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	267	33		
2 L/MIN			77	39
TIME OF CLOUD ARRIVAL	21.22½		21.22½	
TIME OF CLOUD DEPARTURE	21.24¼		21.23½	
TIME CLOUD PRESENT (MINUTES)	1¾		1	
MEAN CELLS/LITRE				
CYCLONE	242		328	
CASCADE IMP	157		320	
MEAN PARTICLES/LITRE	19		39	
PEAK PARTICLES/LITRE	54		56	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	12.7		8.4	
CASCADE IMP/SLIT SAMPLER	8.3		8.2	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	54		28	
2	26		51	
3	16		19	
4	4		2	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	1350	1830
CASCADE IMP	876	1786
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	71	47
CASCADE IMP/SLIT SAMPLER	46	46

SUSPENSION VIABLE BG 0.47×10^{10}/ml

ESTIMATED SM 2.15×10^{10}/ml

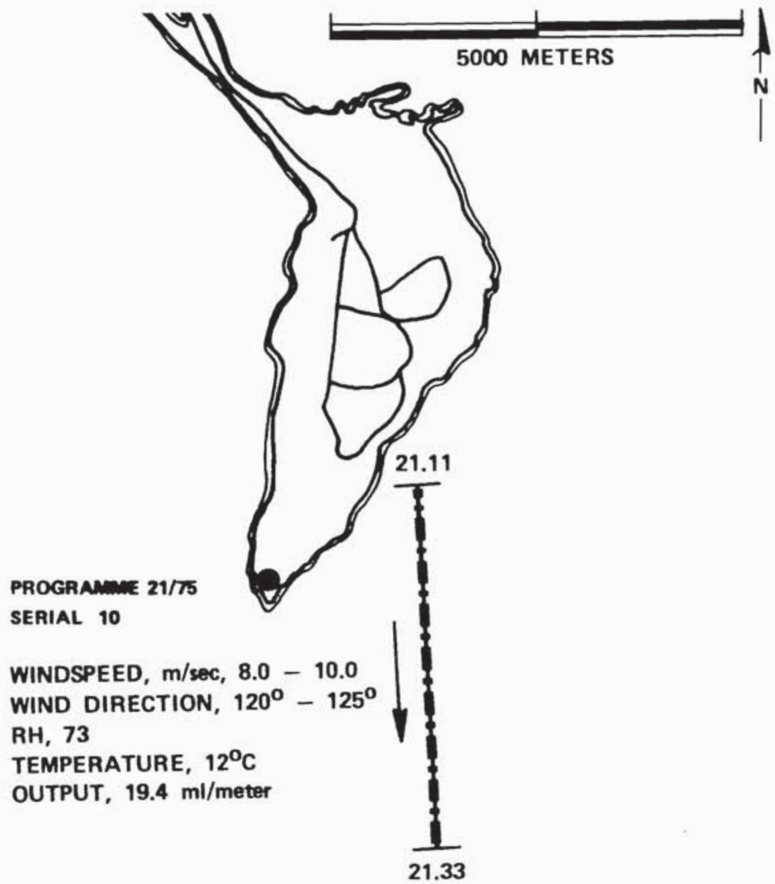

Figure B-37 (C). Challenge 20 – 19 October 1975 (U)

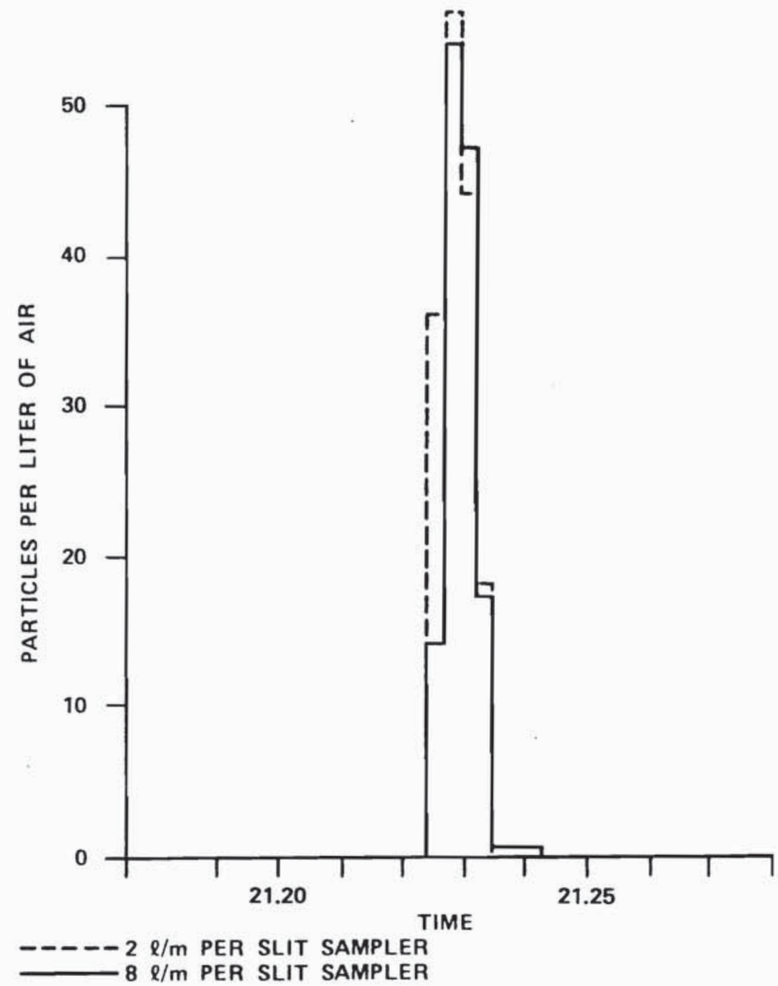

Figure B-38 (C). Challenge 20 – 19 October 1975 (U)

~~CONFIDENTIAL~~

Table B-21 ~~(C)~~

PROGRAMME 21/75 SERIAL 11 DATE 21 Oct. 75 CHALLENGE 21

MATERIAL SPRAYED ISM/BG TIME SPRAYED 12.18 to 12.50 VOLUME SPRAYED 120 litres

LENGTH OF SPRAY LINE 5370 m. RANGE TO SAMPLING SITE 3710 to 5000 m

MEAN WIND SPEED 6 to 8 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	1114	221	1409	364
CASCADE IMP	949	558	624	367
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	TNTC	–		
2 L/MIN			83	42
TIME OF CLOUD ARRIVAL	12.41½		12.41½	
TIME OF CLOUD DEPARTURE	12.45		12.44	
TIME CLOUD PRESENT (MINUTES)	3½		2½	
MEAN CELLS/LITRE				
CYCLONE	63		146	
CASCADE IMP	159		147	
MEAN PARTICLES/LITRE	–		17	
PEAK PARTICLES/LITRE	–		38	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	–		8.6	
CASCADE IMP/SLIT SAMPLER	–		8.6	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	42		29	
2	39		37	
3	16		23	
4	3		11	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	352	815
CASCADE IMP	887	820
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	–	48
CASCADE IMP/SLIT SAMPLER	–	48

SUSPENSION VIABLE BG 0.44×10^{10}/ml

ESTIMATED SM 2.02×10^{10}/ml

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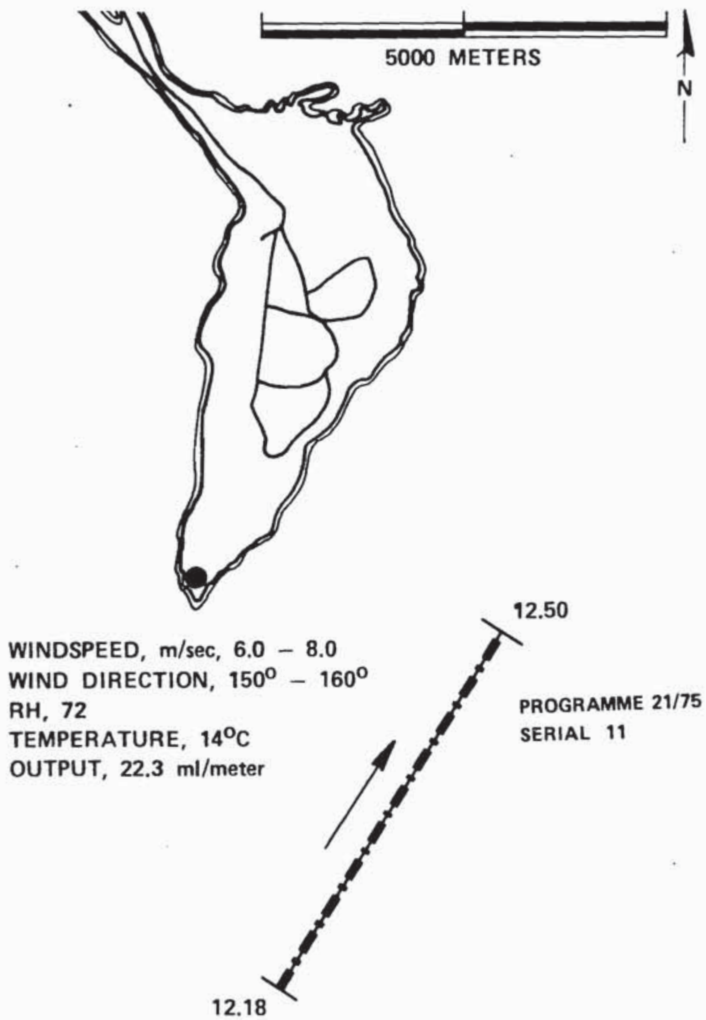

Figure B-39 ~~(C)~~ Challenge 21 – 21 October 1975 (U)

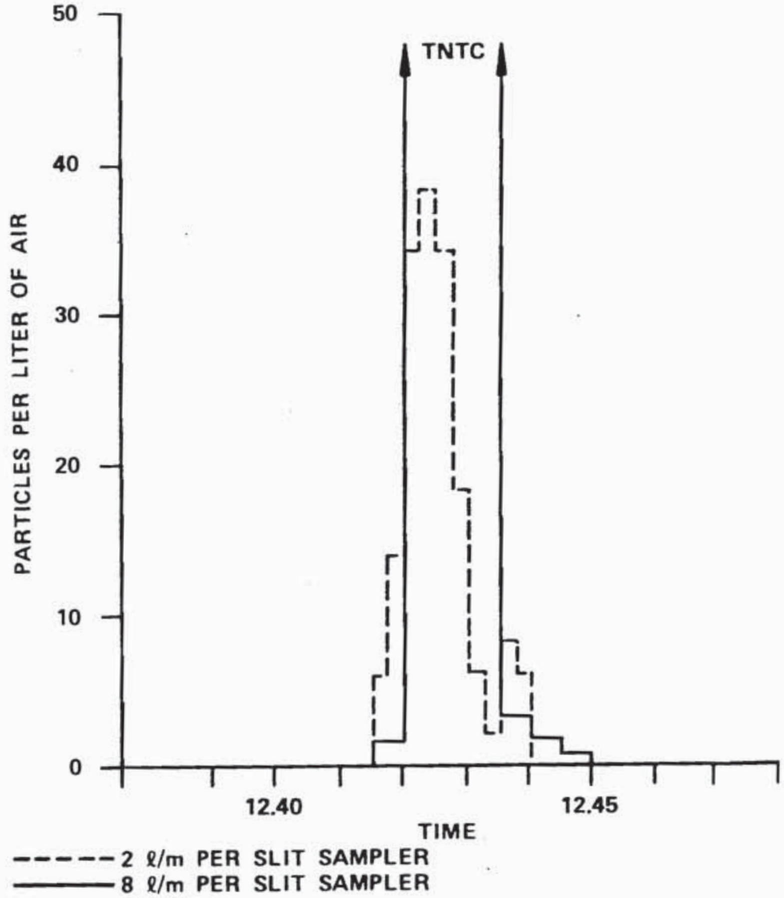

Figure B-40 ~~(C)~~ Challenge 21 – 21 October 1975 (U)

~~CONFIDENTIAL~~

Table B-22 ~~(C)~~

PROGRAMME 21/75 SERIAL 11 DATE 21 Oct. 75 CHALLENGE 22

MATERIAL SPRAYED ISM/BG TIME SPRAYED 13.28 to 13.56 VOLUME SPRAYED 117 litres

LENGTH OF SPRAY LINE 7970 m. RANGE TO SAMPLING SITE 2960 to 5740 m

MEAN WIND SPEED 5 to 8 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	2613	994	2382	927
CASCADE IMP	1758	1034	1350	794
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	TNTC	–		
2 L/MIN			86	43
TIME OF CLOUD ARRIVAL	13.39½		13.39¾	
TIME OF CLOUD DEPARTURE	13.42½		13.42¼	
TIME CLOUD PRESENT (MINUTES)	3		2½	
MEAN CELLS/LITRE				
CYCLONE	331		371	
CASCADE IMP	345		318	
MEAN PARTICLES/LITRE	–		17	
PEAK PARTICLES/LITRE	–		52	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	–		21.8	
CASCADE IMP/SLIT SAMPLER	–		18.7	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	40		22	
2	38		51	
3	15		24	
4	7		3	

II ESTIMATED TOTAL CELLS SM + BG RATIO ESTIMATED SM + BG/BG 5.58

MEAN CELLS/LITRE		
CYCLONE	1847	2070
CASCADE IMP	1925	1774
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	–	122
CASCADE IMP/SLIT SAMPLER	–	104

SUSPENSION VIABLE BG 0.44×10^{10}/ml

ESTIMATED SM 2.02×10^{10}/ml

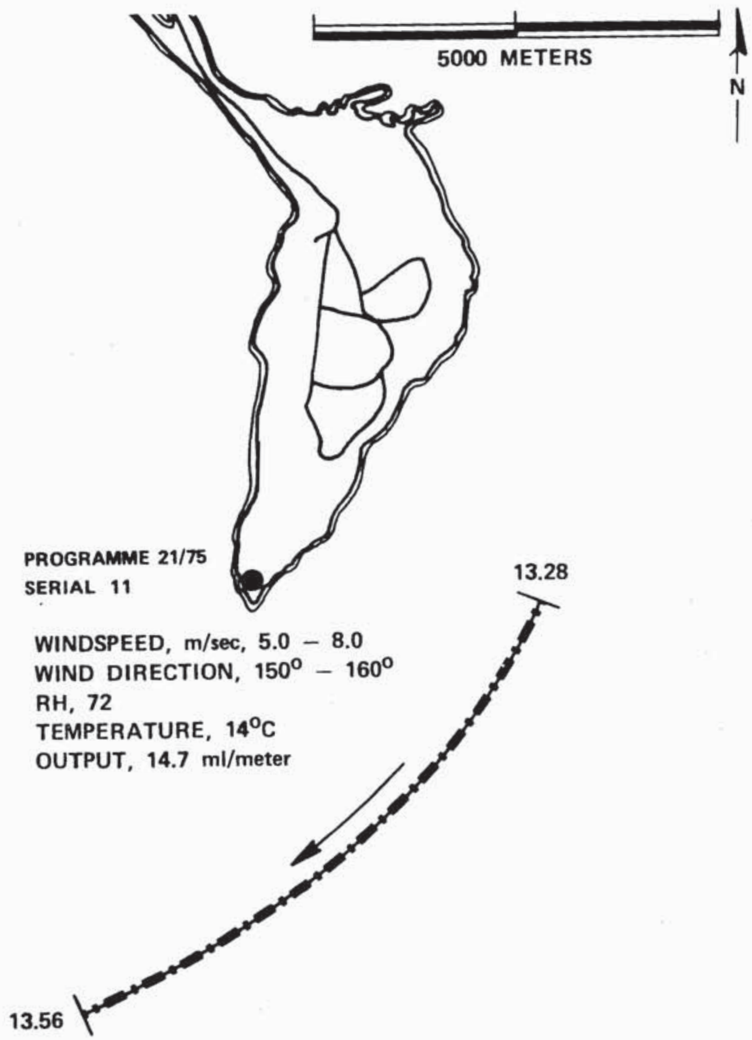

Figure B-41 ~~(C)~~. Challenge 22 – 21 October 1975 (U)

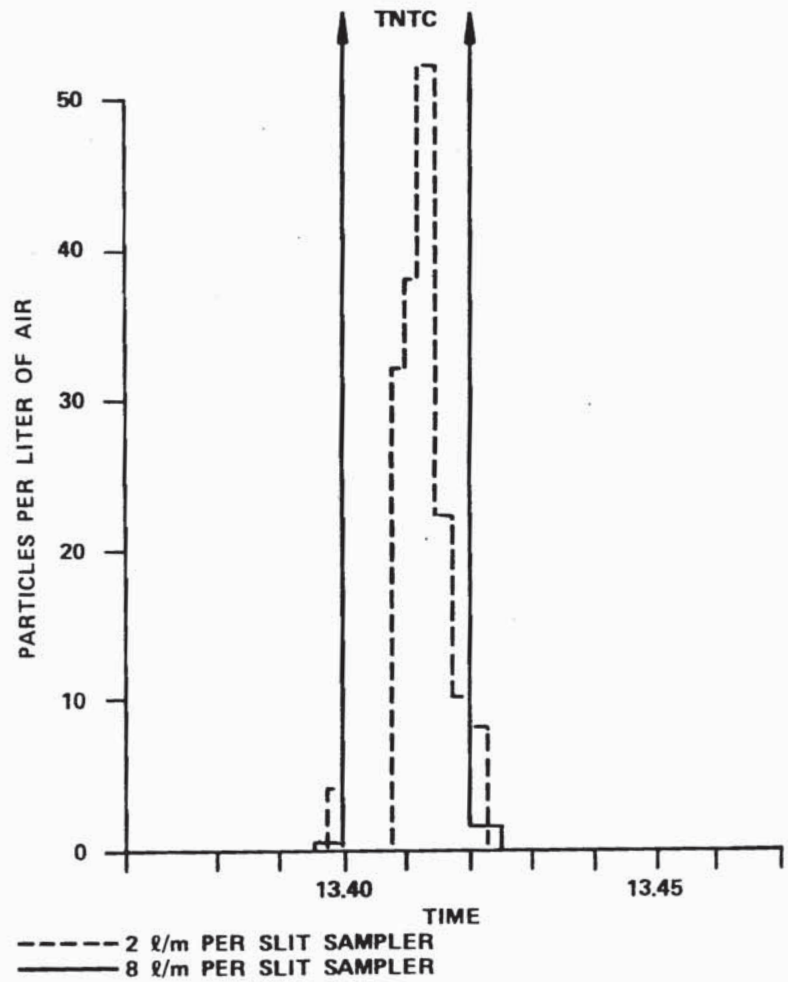

Figure B-42 ~~(C)~~. Challenge 22 – 21 October 1975 (U)

Table B-23 ~~(C)~~

PROGRAMME 21/75 **SERIAL** 11 **DATE** 21 Oct. 75 **CHALLENGE** 23

MATERIAL SPRAYED ISM/BG **TIME SPRAYED** 14.27 to 15.02 **VOLUME SPRAYED** 130 litres

LENGTH OF SPRAY LINE 5370 m. **RANGE TO SAMPLING SITE** 3700 to 5280 m

MEAN WIND SPEED 5 to 8 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	1251	411	1020	351
CASCADE IMP	1184	696	727	427
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	TNTC	–		
2 L/MIN			95	48
TIME OF CLOUD ARRIVAL	15.01½		15.01½	
TIME OF CLOUD DEPARTURE	15.06¼		15.06¼	
TIME CLOUD PRESENT (MINUTES)	5		4¾	
MEAN CELLS/LITRE				
CYCLONE	82		74	
CASCADE IMP	139		90	
MEAN PARTICLES/LITRE	–		10	
PEAK PARTICLES/LITRE	–		30	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	–		7.4	
CASCADE IMP/SLIT SAMPLER	–		9.0	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	35		26	
2	39		49	
3	21		21	
4	5		4	

II ESTIMATED TOTAL CELLS SM + BG **RATIO ESTIMATED SM + BG/BG** 5.58

MEAN CELLS/LITRE		
CYCLONE	458	413
CASCADE IMP	776	502
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	–	41
CASCADE IMP/SLIT SAMPLER	–	50

SUSPENSION **VIABLE BG** 0.37×10^{10}/ml

ESTIMATED SM 1.69×10^{10}/ml

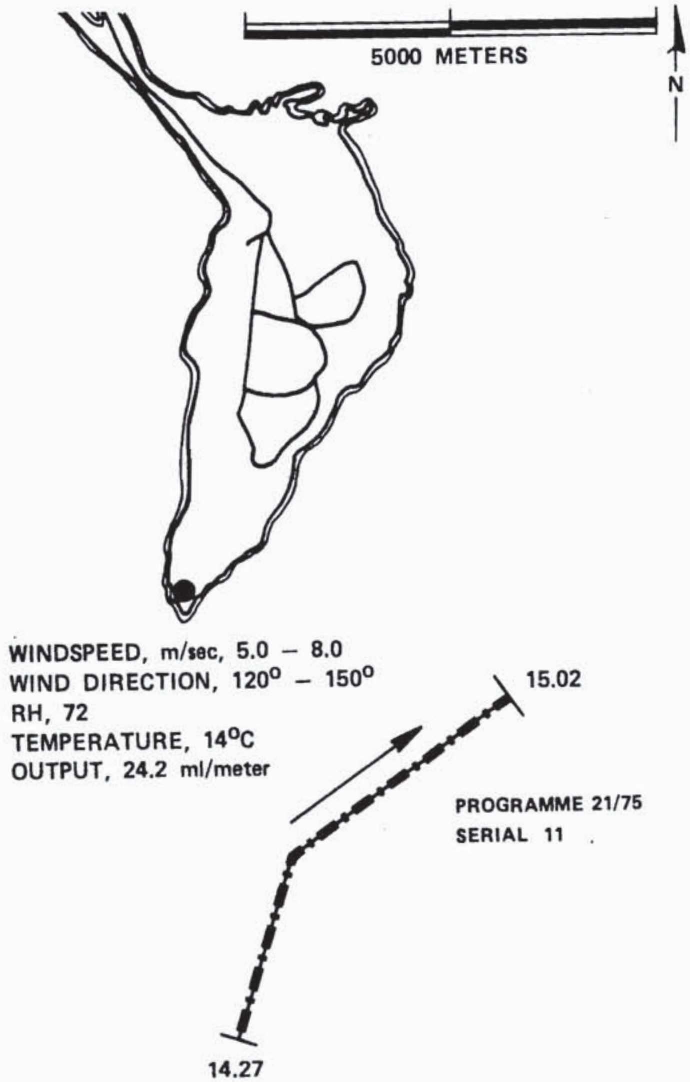

Figure B-43 ~~(C)~~. Challenge 23 – 21 October 1975 (U)

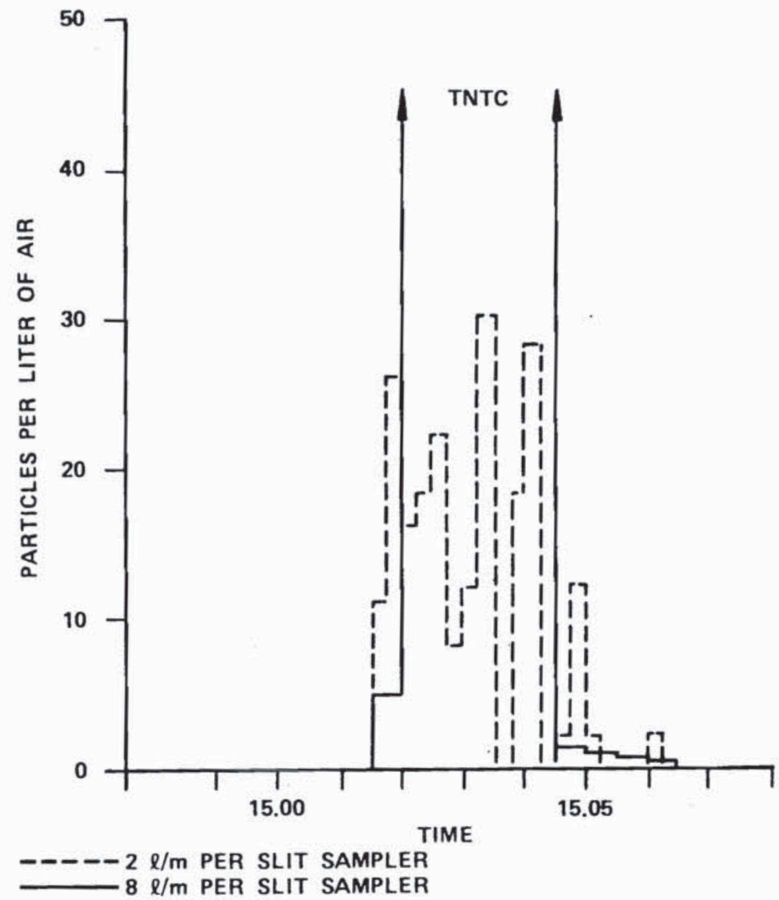

Figure B-44 ~~(C)~~. Challenge 23 – 21 October 1975 (U)

Table B-24 ~~(C)~~

PROGRAMME 21/75 **SERIAL** 11 **DATE** 21 Oct. 75 **CHALLENGE** 24

MATERIAL SPRAYED ISM/BG **TIME SPRAYED** 15.28 to 15.55 **VOLUME SPRAYED** 108 litres

LENGTH OF SPRAY LINE 7500 m. **RANGE TO SAMPLING SITE** 3100 to 4820 m

MEAN WIND SPEED 6 to 10 m/s

RESULTS OF ASSESSMENT

I VIABLE BG RECOVERIES

	RED		BLUE	
	SAMPLING SITE 1		SAMPLING SITE 2	
	NO. OF COLONIES COUNTED	DOSAGE Nt	NO. OF COLONIES COUNTED	DOSAGE Nt
CELL DOSAGE				
CYCLONE	1757	186	854	209
CASCADE IMP	432	254	417	245
PARTICLE DOSAGE				
SLIT SAMPLER 8 L/MIN	TNTC	–		
2 L/MIN			44	22
TIME OF CLOUD ARRIVAL	15.43½		15.43½	
TIME OF CLOUD DEPARTURE	15.45¾		15.45¾	
TIME CLOUD PRESENT (MINUTES)	2¼		2¼	
MEAN CELLS/LITRE				
CYCLONE	83		93	
CASCADE IMP	113		109	
MEAN PARTICLES/LITRE	–		9.8	
PEAK PARTICLES/LITRE	–		30	
MEAN CELLS/PARTICLE				
CYCLONE/SLIT SAMPLER	–		9.5	
CASCADE IMP/SLIT SAMPLER	–		11.1	
DISTRIBUTION OF BG IN CASCADE IMPACTOR				
% ON STAGE 1	33		5	
2	46		66	
3	19		23	
4	2		6	

II ESTIMATED TOTAL CELLS SM + BG **RATIO ESTIMATED SM + BG/BG** 5.58

MEAN CELLS/LITRE		
CYCLONE	463	519
CASCADE IMP	631	608
MEAN CELLS/PARTICLE		
CYCLONE/SLIT SAMPLER	–	53
CASCADE IMP/SLIT SAMPLER	–	62

SUSPENSION **VIABLE BG** 0.46×10^{10}/ml

ESTIMATED SM 2.11×10^{10}/ml

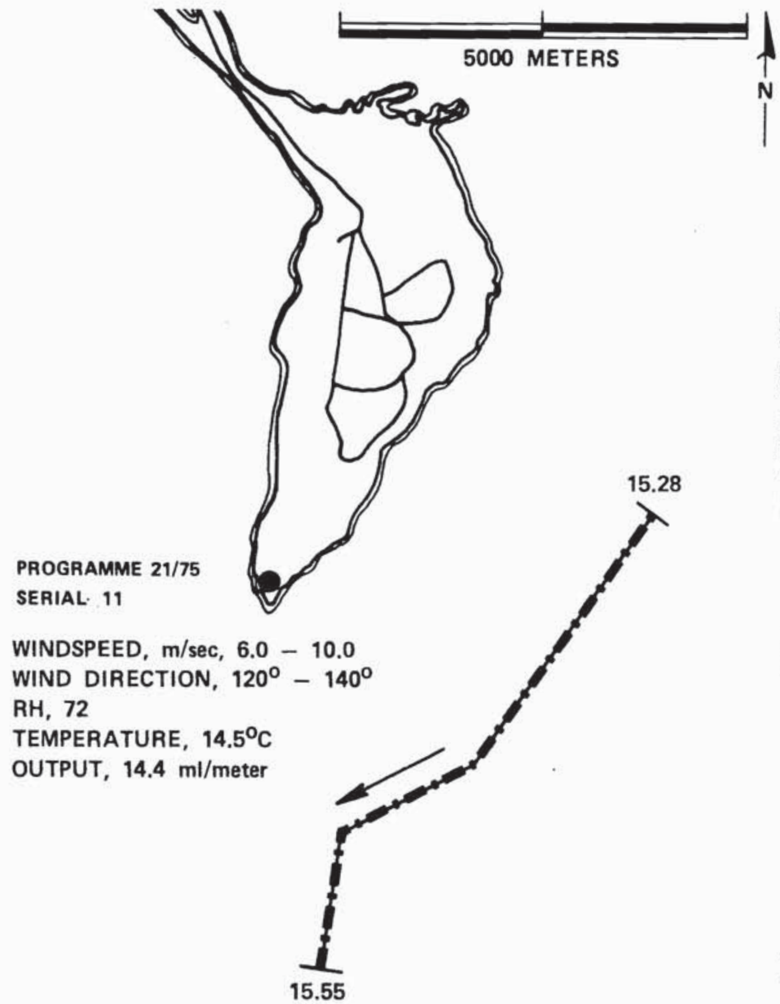

Figure B-45 (C). Challenge 24 – 21 October 1975 (U)

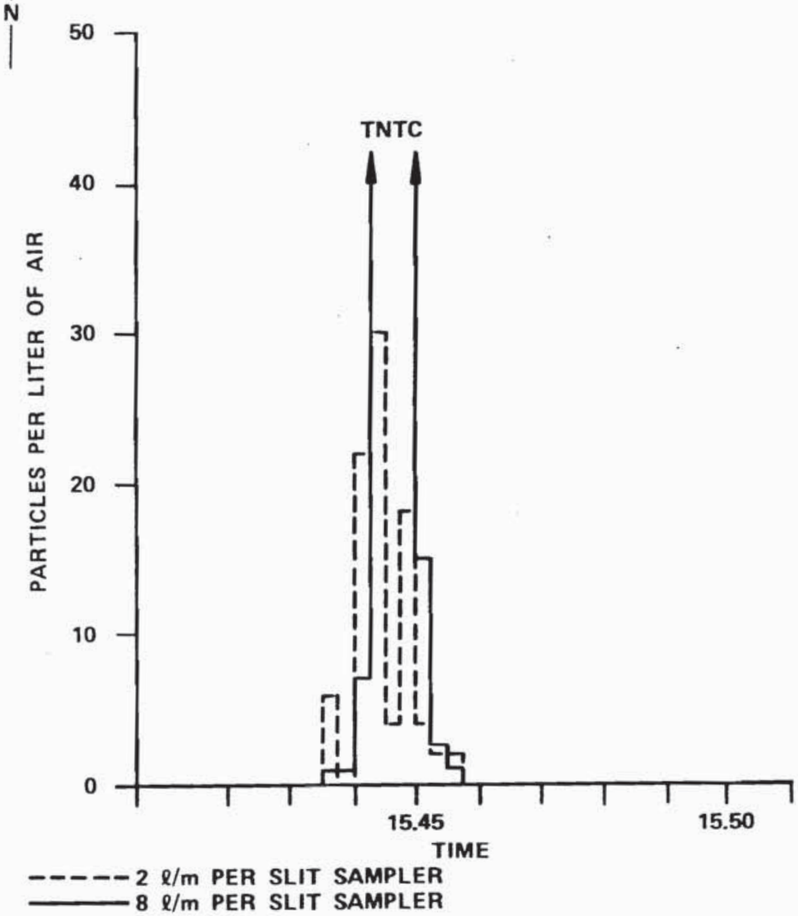

Figure B-46 (C). Challenge 24 – 21 October 1975 (U)

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